RADIO and ELECTRONICS

Included in this Issue:

USING MINIATURE TUBES
DESIGN SHEET No. 2
RADAR
"PROGRESSIVE"
A CAPACITY ANALYSER
RADEL DUAL-WAVE FIVE
RADEL BATTERY THREE

SEPTEMBER 1st, 1946

1'6

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RADIO and ELECTRONICS

Vol. 1 No. 6 September 1st, 1946

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OUR COVER this month illustrates one of the latest British mobile microwave radar sets. Manufactured by B.T.H., it was known by the code name of "Glaxo." Its purpose is the control of A.A. gunfire, and it embodies some startling developments, chief among which is the ability, once set on a target, to track it automatically. The single "dish" acts as both transmitting and receiving aerial.

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All correspondence, contributions, and enquiries referring to advertising space and rates should be addressed to:—

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GUY E. MILNE
ELECTRONIC TECHNICIAN

Back on All Bands

July, 1946, was a notable month for amateur radio transmitters. Until then, the only bands to be reopened after the war were the 80 and 10-metre bands. On 80, only communication within New Zealand was allowed, but on 10, both 'phone and C.W. were available on a world-wide basis. Coincidental with the lifting of the local restrictions on the use of the 80-metre band, came the news that the 40 and 20-metre bands also were restored. The old 160-metre band, the Postmaster-General stated, will not be restored, but as compensation an extra high-frequency band, 21,100 to 21,500 kc/s., would be available to amateurs within a few months. In addition, the old 5-metre band is discontinued and is replaced by the band 50 to 54 mc/s. Twenty-metre 'phone is still not allowed in this country, but will be considered later. The Postmaster-General's statement indicated that the bands at present allotted for use by amateurs are by no means fixed, nor will they become so until after the next international radio communication conference.

Amateur transmitters are, no doubt, delighted at the restoration of some of their pre-war privileges. During the war years, gloomy prophets within their ranks foretold disaster by proclaiming that, after the war, it was doubtful whether much, if any, of the ether space formerly used by them would be restored, but, far from these forebodings being realised, it now appears that the amateur is receiving much more consideration than he has done in the past. For, in addition to the bands mentioned above, numerous ultra-high-frequency bands will be available to him after the final allotment has taken place. Even now, the bands 166 to 170 mc/s., 420 to 450 mc/s., and 1345 to 1425 mc/s. have been made available.

Consideration of the amateur's present situation shows that the authorities in this country, as elsewhere, are fully alive to the importance of having a flourishing community of amateur technicians and operators. Indeed, were it not so, the position would be serious, for the recent war has brought home to most of us the extreme importance in time of emergency of trained technical personnel, who can be used in the country's defence at a moment's notice.

Without doubt, however, there are many amateurs who will wish to know why the harmonic relationship of their bands, to some extent, has been upset. True, the point is not one of very great importance, as it affects only the lower of the ultra-high-frequency bands. Crystal control on 5 metres will no longer be possible with 3.5 or 7 mc/s. crystals. As yet, the old 112 mc/s. and 224 mc/s. bands have not been restored, nor has any pronouncement upon them been made. It would appear that these may have been lost altogether. This is unfortunate in some ways, since there is a very large gap between the techniques applicable to the 50 mc/s. band and the 170 mc/s. band, and a greater one still between this and the two highest bands. Many amateurs will be but little affected by the new ultra-high-frequency allocations, since their tastes lie in the direction of the lower frequencies. But to those who are keen experimenters, the difficulties introduced, both by the new anharmonic arrangements and by the allocation of the V.H.F. bands, will come more as an incentive to further work and knowledge than as a nuisance, and to this extent the allocation will serve a useful and a productive purpose.

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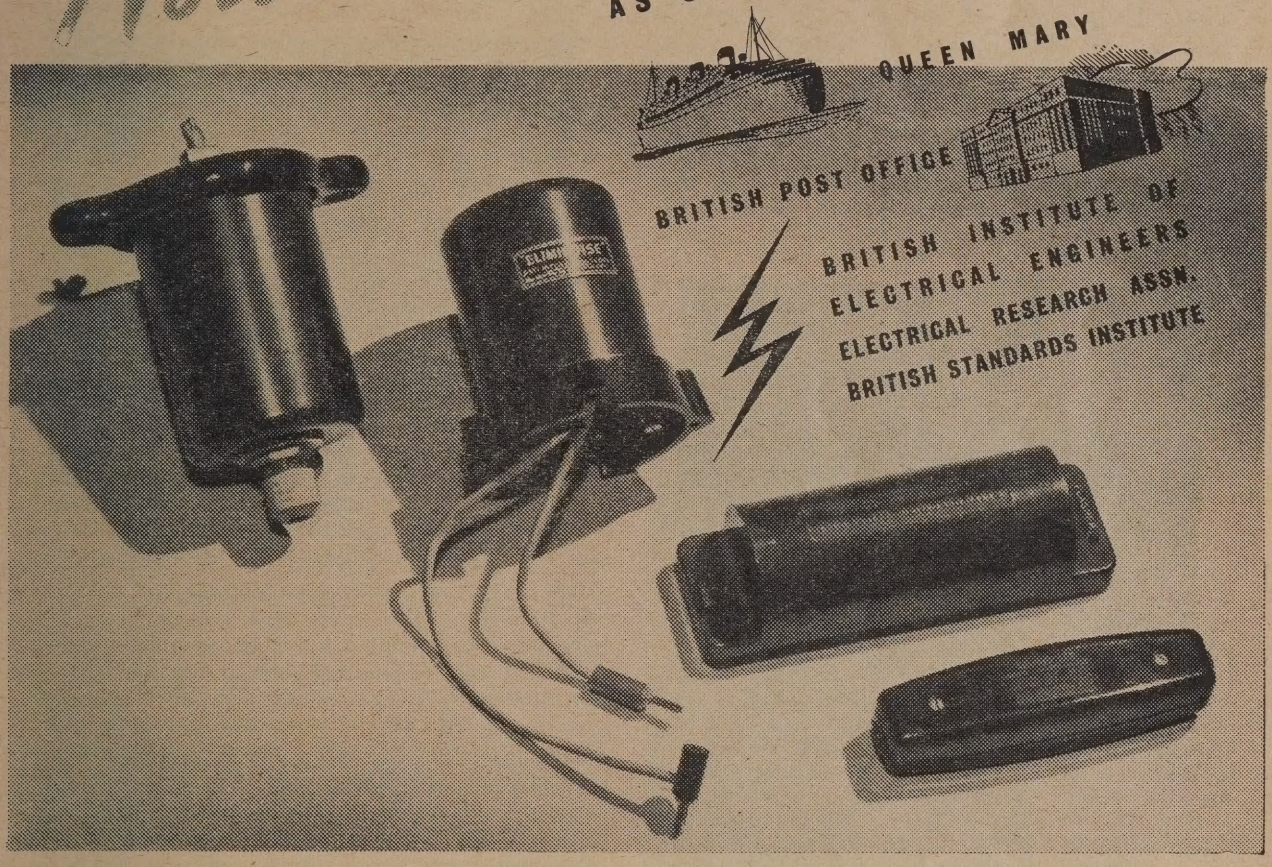

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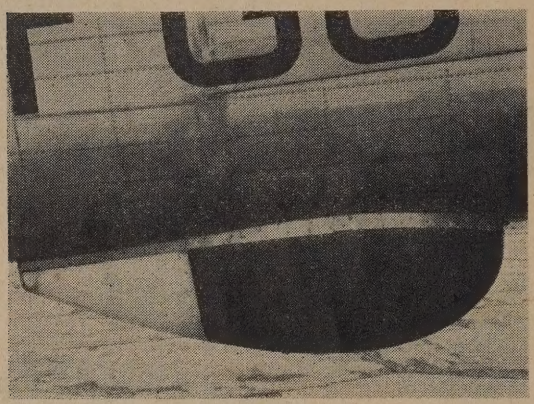
RADAR

H_2S, OR THE "GEN-BOX."

Although radar was originally conceived by the R.A.F. as a defensive weapon, in which role it played a major part in the victorious Battle of Britain, it became obvious to the "powers that be" that it could be developed to an almost unlimited extent as an offensive weapon. Quite early in the war, the R.A.F. had commenced a night-bombing onslaught on Germany, but it was found that the difficulties of navigation, target identification, and extreme weather conditions caused the results obtained to be very small in comparison with the effort expended. The methods that could make day bombing a success, provided the defence was not impossibly strong, were inapplicable at night, as, for example, raids by large formations. At night individual navigation, target identification, and bombing had to be carried out by each aircraft. So alive were the higher ranks of the R.A.F. to the possibilities of radar as an offensive weapon, that not long after the beginning of the first Bomber Command offensive, the problems we have mentioned were placed before British scientists, who were given the job of finding out just how radar could help in their solution.



Perspex "blister," fitted to the Lancaster, is a covering for the scanner and is 8ft. long and 3ft. wide, the forward end painted to eliminate searchlight deflection. The unpainted area is housing navigation lights.

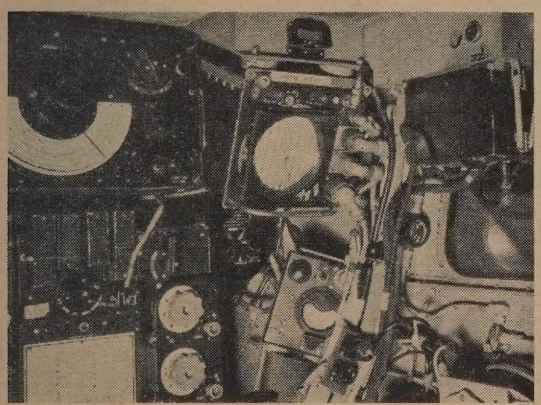
As a result, many radar equipments were developed which were entirely offensive in nature or else enabled functions to be performed which indirectly assisted the R.A.F. to produce the shattering blows which by themselves in the later years of the war almost pounded Germany to submission.

High on the list of radar weapons comes H_2S, whose purpose was to allow identification of targets under any conditions of weather, and which enabled accurate bombing runs to be made without ever a sight of the target. Incidentally, H_2S is the equipment first described to the public while its operating details were still "secret," as the "Gen-box."

It uses no principles which have not been described in our previous articles on radar. It transmits pulses and receives them back after reflection by solid objects. It has a P.P.I. display tube exactly similar in principle to the one described in the June issue of *Radio and Electronics*. Its signal frequency is in the centimetre region, however, which, though now commonplace, was far from general in 1943, when H_2S was first operational. In fact, H_2S was one of the earliest operational equipments to use the centimetre wavelengths. This it was able to do by virtue of the researches carried out by British scientists on the improvement of the magnetron, which, before the war, was nothing but a scientific curiosity. The advantages conferred by the centimetre wavelengths upon an equipment using the P.P.I. are very great, but are mainly in the direction of increased discrimination. The first sets to use the P.P.I. were the British C.H.L. radars, used for long-range low-flying air-warning cover round the British coast. These had a signal frequency of 200 mc/s., which in 1941 was considered high. The discrimination achieved by the C.H.L. was ample for its purpose, since its screen ideally showed nothing in the absence of an aircraft target.

Early in the development of airborne blind-bombing equipment, it was realised that, if the terrific advantages of the newly-developed P.P.I. presentation were to be fully realised, higher and higher signal frequencies would have to be used. A potent reason for this was that the discrimination achieved by the C.H.L. was not nearly great enough for airborne purposes, and at this frequency an aerial giving sufficient discrimination would have been much too large and heavy to carry in an aircraft. In order to differentiate be-

tween small objects close together, a very narrow beam is necessary. It was imperative, therefore, to raise the signal frequency to the point where a very narrow beam could be obtained with a very small aerial system. At the centimetre wavelength used by H_2S, the beam was produced by means of a parabolic reflector which could be made small enough to allow a continuously rotatable structure to be mounted in the belly of the aircraft. This reflector acted as both transmitting and receiving aerial, alternately, and enabled a P.P.I.

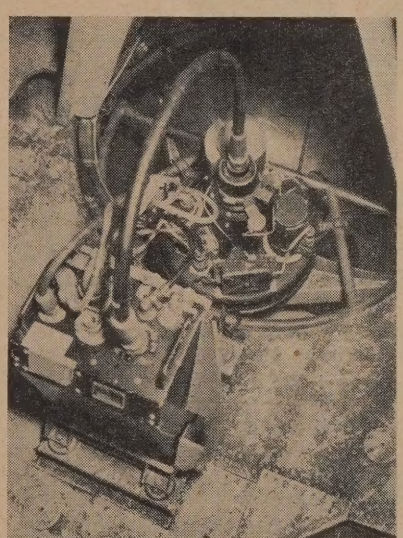


Shows P.P.I. and range tube, range and height indicators. The whole assembly is mounted on a rotatable bracket so that it can swing into position for either the navigator or bomb-aimer to take observations.

display to be presented on account of its continuous rotation.

Although, as we have pointed out, no new radar principle was involved in this scheme, the method of interpretation of the P.P.I. picture was new in so far as a hitherto unused fact was employed. It was this—that, when radiation is directed at the surface of the earth from a great height, the character of the echoes received varies according to the type of terrain over which the aircraft is passing. For example, over a flat sheet of water, energy is hardly reflected back in the direction of the aircraft at all, just as a light beam directed from a height on to a horizontal mirror is reflected forwards and upwards but hardly at all back in the direction of the source of light. Again, if the surface struck by the beam of radiation is rough, some of the energy is reflected back to the aircraft and is seen as a response on the P.P.I. Thus, if an H_2S-equipped aircraft is flying over land in which is a large lake, the lake will be readily apparent on the P.P.I. screen, for the land, being rough, will cause echoes to return, while the sheet of water will not. The effect is that of a blank space in the bright land returns, the shape of the former being a fairly accurate representation of its actual configuration.

It is easily seen from the above that H_2S enables the operator to follow quite easily the courses of rivers and to identify lakes or smaller sheets of water by their shape. But the story does not end here, for different types of land give vastly different types of echo, and so can be identified on the H_2S P.P.I. screen. Open, rolling farmland, for instance, gives a return echo, but only a small one. A range of hills will give a very solid return compared with the flat surrounding country, and so can be identified easily. Most important of all, built-up areas, such as large towns, also give very strong returns, so that it is quite possible to identify a city under certain conditions. During the actual bombing offensive by means of H_2S, reconnaissance aircraft were sent out in daylight to observe on their H_2S the exact appearance of likely targets and to bring back photographs of the P.P.I. which could be used in briefing crews for a raid



The picture shows the microwave transmitter mounted on the floor of the fuselage and the heavy co-axial R.F. cable feeding and the scanner, which is mounted below the surface of the fuselage and covered with "blister." illustrated in Fig. 1.

on the place thus inspected by radar. Of course, not all targets were found suitable for H_2S bombing, but many of the important ones were, which accounts for the enormous practical utility of H_2S.

TECHNICAL DIFFICULTES.

One of the major difficulties in the production of H_2S has already been indicated, and was that of making a practicable radar working on

centimetre wavelengths. This difficulty can be appreciated better when it is realised that the fundamental problem was to develop transmitting valves which could produce outputs of 50 kw. and more at these extremely high frequencies. A second problem was that of building sufficiently sensitive receivers. Before the war, such wavelengths had been achieved only in laboratories under carefully-chosen conditions, and it is a very far cry from this to the point where standardised equipment of high power output and sensitivity could be made to function satisfactorily under the extremely rigorous conditions which are met in service aircraft. It is the overcoming of these and other great technical difficulties by British scientists which made possible, not only H_2S, but other equipments which, in turn, allowed us so successfully to carry out the air offensive against Germany.

An interesting point which had to be overcome was the fact that the P.P.I. picture given by H_2S is a true one only when the aircraft is flying straight and level. If evasive action had to be taken while on the way to the target, the equipment could become almost useless, for, if the aircraft dived, the beam from the aerial, instead of passing downwards and outwards, would become directed vertically downwards, so that the screen would be cluttered up with returns from immediately below the aircraft, and anything which was being observed at some distance would disappear. Similarly, should the aircraft climb, the beam would be directed over the top of the target, which would again be lost. If the aircraft banked, the whole picture would slide sideways off the screen. To overcome this, a special stabilising system had to be applied, which, worked by gyroscopes, ensured that whatever the attitude of the aircraft, the beam from the scanning aerial system always approached the earth at the correct angle.

This, though a mechanical problem, is a good example of the extreme attention to detail which must be applied in turning a workable principle into a practicable piece of equipment. Although the above description is, of necessity, a brief one, it does give some idea of the skill and technical adaptability required of our scientists and designers, and of the way in which a multitude of separate inter-related problems, both mechanical and electrical, had to be solved in order to

(*Continued on page* 45.)

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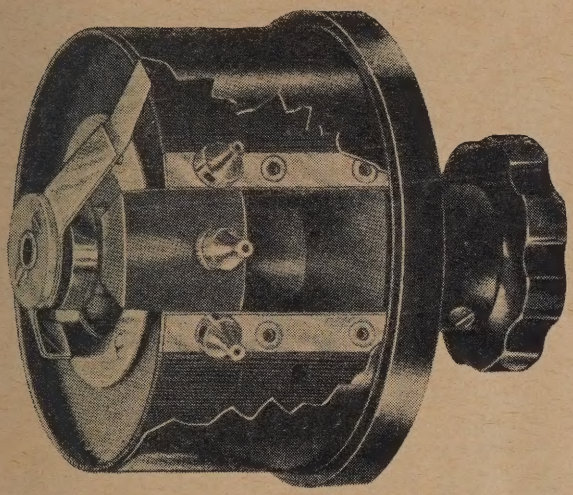

CV25 Potentiometer Features

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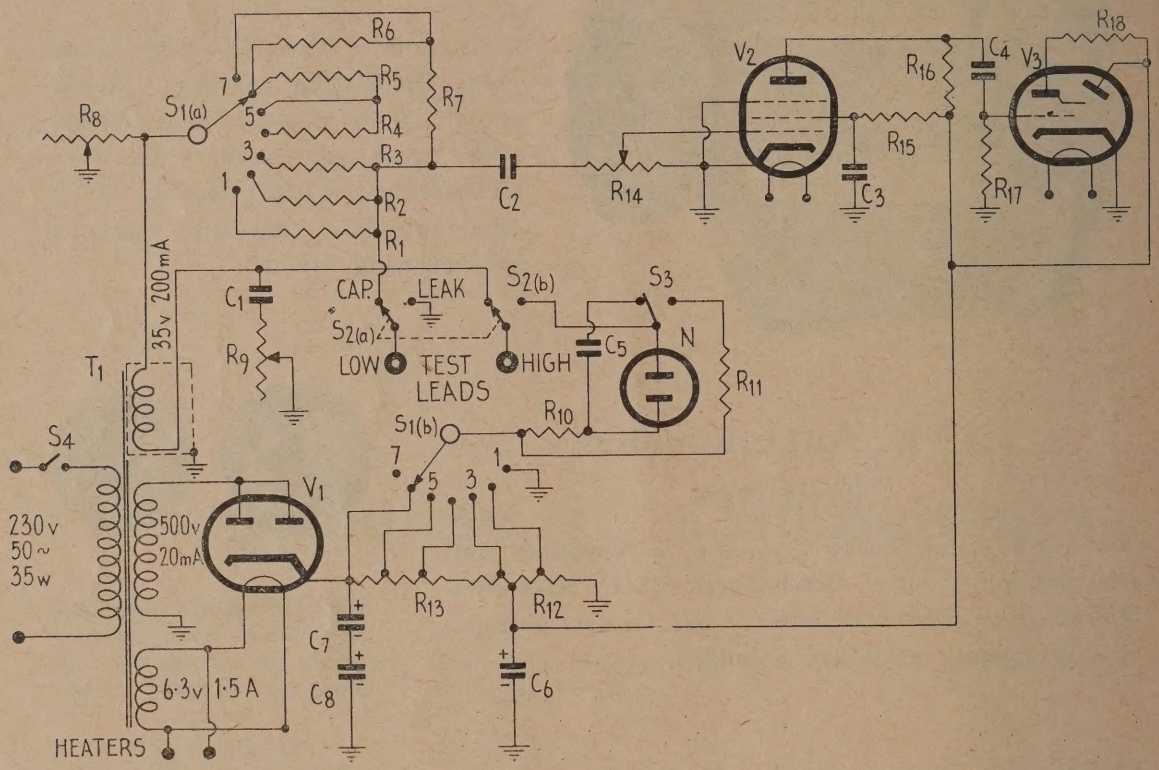
A BRIDGE TYPE CAPACITY ANALYSER

By "ELECTRON."

The need for the means of testing all types of condensers for both capacity and leakage (power factor) has stirred the writer into designing a combined capacity bridge and leakage tester, which is described in the following paragraphs.

For measuring the value of condensers, a resistance-capacitance bridge circuit is used, with a power supply of 50 c/sec. and a magic eye null indicator. To increase sensitivity and to isolate the indicator from the bridge itself, a 6J7 amplifier is used. The range of the instru-



COMPONENT LIST

T_1 = Power transformer. Windings as indicated.
V_1 = 6X5.
V_2 = 6J7.
V_3 = 6E5.
N = $\frac{1}{4}$ watt neon lamp.
S1(a) and S1(b) = Range switch.
S2(a) and S2(b) = Leakage/Capacity switch.
S_3 = Paper or mica/electrolytic switch.
S_4 = On/Off switch on R_{14}.
R_1, R_{18} = 1 meg.
R_2 = 100k.
R_3 = 10k.
R_4 = 900 ω
R_5 = 90 ω
R_6 = 9 ω
R_7 = 0.9965 ω
R_8 = 10kw-w. pot.
R_9 = 15k. w-w. pot.
R_{10} = 120k.
R_{11} = 30k.
R_{12}, R_{13} = 25k. voltage divider, two taps.
R_{14} = 1 meg. pot.
R_{15} = 2 megs.
R_{16}, R_{17} = 500k.
C_1 = 0.099 μf.
C_2, C_4 = 0.01 μf.
C_3 = 0.25 μf.
C_5 = 0.5 μf.
C_6–C_8 = 8 μf. 450v. electro.

ment is from 10$\mu\mu f$. to 1000 μf. in 7 steps while power factor at 50 c/sec. is measured from 0 to 50 per cent. The voltages available for D.C. leakage tests are 100, 200, 300, 400, and 500 volts. The analyser is comparatively simple to construct and should prove one of the most valued pieces of equipment on the test bench.

CHOICE OF COMPONENTS.

The transformer, as can be seen from the circuit diagram, Fig. 1, is a special one and will have to be ordered from a firm which undertakes this type of work. It will be noted that the 35-volt bridge supply winding is shown completely surrounded by an electrostatic shield. This is very important if a sharp, clear null indication is to be obtained on the magic eye.

While the accuracy of the complete instrument depends on that of the components, and especially on the resistors and condenser in the bridge circuit, expensive low tolerance components need not be used. Stock resistors, carefully chosen for value, are quite satisfactory, and the 0.099μf. condenser in series with the power factor control is not very critical. This may be 0.1 μf. (nominal), which measures slightly low, but should not be higher than 0.1 μf if the power factor control is to give reliable readings. The multiplier resistors should be of the 1-watt carbon type, carefully selected to within 1 per cent. of the value indicated in the component list. The three lower values R_5, R_6, and R_7 can be made by the constructor from resistance wire mounted on thin cards of insulating material. This should be thin in order to reduce the inductance of the resistor, but it is unnecessary to go to the length of using a special non-inductive winding method. R_{12} and R_{13}, the voltage dividers which provide the previously-mentioned voltages for D.C. leakage testing, should be rated at 10 watts as a minimum, but preferably at 25 watts, so as to reduce temperature rise.

CONSTRUCTIONAL DETAILS.

The layout of parts used in wiring up the circuit is not very important, except for one point. V_2 and V_3 and the whole of the bridge circuit should be as far as possible from the power transformer. This is to prevent induction into the bridge or the indicator circuit, which, if present, will render accurate balancing of the bridge extremely difficult. Apart from this, the layout of parts can be governed by the need for arranging the controls in a pleasing manner on the panel of the instrument. R_8, the resistor used to obtain balance, should preferably be mounted centrally, with room round the shaft for a 270-degree scale at least two inches in radius, but preferably larger. The other controls can be grouped round the main scale in any convenient fashion. A pointer for the main scale should be made from heavy celluloid, or similar material, with a hairline down the centre and fixed to the back of a skirted instrument knob which has had the skirt removed, making the mounting screws available for attaching the pointer.

A hood should be placed round the magic eye to facilitate observation in a well-lighted room. It can be made from the type of valve shield used for the straight-sided GT/G valves, should be painted black inside and out, and slipped over the magic-eye tube. It is an easy matter to arrange for it to extend through the front panel, the extension being adjustable by simply pulling the shield in or out.

When wiring up the components, it is best to use bare tinned copper wire of heavy gauge (18 is suggested), so that the unavoidable stray capacities associated with the bridge will at least be constant in value, and can in any case be kept small by suitably spacing the rigid leads.

OPERATING THE INSTRUMENT.

Although, strictly speaking, calibration should be described next, we will assume for the moment that this has been completed, and describe how the analyser is used, for a theoretical discussion has purposely been omitted on the score of brevity, and until operating details are known, it is impossible to perform the calibration.

To Measure Capacity:

Switch on the analyser and allow 30 seconds for warming up. Set the "capacity-leakage" switch S_2 to the "capacity" position, turn the power factor control to zero and the sensitivity control to about one-quarter scale. Switch the range selector S_1 to the desired range, and connect the "unknown" condenser across the test terminals. Rotate the balancing control R_8 until maximum opening of the eye is obtained. If the indication is not easily obtained, the sensitivity control should be advanced, and the main dial swung again until a really sharp balance can be observed. When measuring condensers up to 0.05 μf. the power factor control can usually be left at zero. With condensers larger than this, it will be necessary to adjust the power factor control in conjunction with the main dial until a perfectly clean edge can be seen on the eye shadow. Since electrolytic condensers have the

highest power factor, this simultaneous adjustment will always be necessary for them, and will also be needed in measuring paper condensers, which have more than the usual very small leakage.

The main dial is calibrated from 0 to 10, so that the value of the "unknown" condenser will be the dial reading multiplied by the factor indicated by the position of the control knob of S_1, the range selector switch. If it has been necessary to use the power factor control to obtain a balance, the setting of this knob will indicate power factor in per cent. at the bridge frequency of 50 c/sec.

To Check for Leakage:

Set the "capacity-leakage" switch to "leakage" and the "paper-mica-electrolytic" switch to the appropriate position. Set the main selector switch S_1 to the D.C. working voltage of the condenser to be tested, and connect the condenser under test to the test terminals. To see whether the condenser is satisfactory or not refer to the following table:—

Mica and Paper Condensers:

Satisfactory: No glow in leakage neon, or periodic flashes not exceeding one a second.

High Leakage: Steady dull glow or periodic flashes exceeding one a second.

Intermittent: Flashes at irregular intervals. Intermittent leakage may cause flashes at regular intervals, but if this fault is suspected, testing the condenser for capacity will prove or disprove its presence.

Electrolytic Condensers.

Satisfactory: No glow, or steady dull glow disappearing within a few minutes.

High Leakage: Steady dull glow which may go out after several minutes. New condensers, or those which have been unused for several months have to be re-formed, so that the glow will not disappear for some minutes. Removing from the tester and testing again, after a quarter of an hour or so, will show whether the condenser only required forming or was faulty.

Intermittent: A glow which dims or goes out entirely and then increases in brilliance after a few seconds.

CALIBRATION.

Calibrating the main capacity dial is really quite easy, provided due care and a little initiative are used. If a decade condenser box is available, so much the better, but, if not, "known" values of ordinary condenser must be used. The procedure is to perform the capacity test with each "known" condenser, marking the dial settings for each with its nominal value. It is a good plan to use a number of condensers of the same nominal value, which will give a series of closely-spaced points, the average position of which may be taken as the correct reading for that value. By means of a little juggling with series and parallel arrangements, a number of non-standard values may be obtained. It is necessary to calibrate only one range of capacity, for, if the multiplier resistors are accurate, the other ranges must be correct. It is well worth while going to some trouble over the calibration, as upon this depends the worth of the whole instrument. An excellent scheme is to use a temporary scale for the main dial, calibrated from 0 to 100, and, instead of marking the points for the various condensers directly on the scale, note the scale reading for each one, and plot the points obtained on a graph of dial reading against nominal capacity. When sufficient points have been obtained, a smooth curve is drawn through the points, and from this, scale readings for condensers of any value within the range may be read from the graph, and a new scale constructed, using the most convenient calibration marks.

The power factor control is calibrated as follows: First, the resistor is disconnected from C_1 and turned fully anti-clockwise. With the ohm meter the two lugs thereby short-circuited are found. The position of the pointer is labelled 0. The ohm-meter is connected to the terminals indicated, and the control is turned in a clockwise direction until the ohm-meter reads 317 ohms. The position of the pointer is marked 1 per cent. The other points up to 50 per cent. are calibrated by continuing the clockwise rotation and marking the points at which the ohm-meter reads the figures in the table below.

1%	317 ohms		20%	6,450 ohms	
2%	645 ohms		25%	8,200 ohms	
3%	965 ohms		30%	9,650 ohms	
4%	1,280 ohms		35%	11,400 ohms	
5%	1,590 ohms		40%	12,800 ohms	
10%	3,220 ohms		45%	14,500 ohms	
15%	4,900 ohms		50%	15,900 ohms	

Table for Power Factor Measurements:

As mentioned above, electrolytic condensers may need forming, but this can be done by connecting them for a few moments in the leakage-test position. Paper condensers should never give an appreciable power-factor reading, while

(*Concluded on page* 48.)

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LETTERS TO THE EDITOR

Sir,—As you are no doubt aware, during the past year two overseas publications have featured a series of published letters dealing with suggestions from radio servicemen as to how manufacturers of post-war receivers could make their products more satisfactory from the point of view of subsequent servicing.

Whilst I am of the opinion that servicemen in New Zealand have little to complain of in comparison with other countries, I would nevertheless like to set the ball rolling by offering the following list of suggestions. The list is not intended to be complete, but merely to be some of the commoner unnecessary headaches which the average serviceman is likely to encounter.

1. Manufacturer's model and serial number to be stamped on chassis or on metal plate affixed to chassis.

2. Loud-speakers to be provided with plug and socket except when integral with chassis.

3. Intermediate frequency peak to be stamped on chassis or on I.F. coil cans.

4. Some means of supporting chassis in an inverted position on test bench required, e.g., an internally-threaded bush or nut welded or riveted on top of chassis at each corner, into which could be screwed lengths of metal rod. Such rods thus forming four legs which would support an inverted chassis without damage to dial or valves, etc.

5. Dials to be fixed completely to chassis, no scales or parts of dials to be fitted inside the cabinet.

6. Valve sockets not to be covered by other components or by wave-change switches and to be reasonably accessible in order to facilitate the taking of voltage readings.

7. General mounting of components to be such as to allow reasonably easy access for replacement purposes, e.g., in vibrator sets—vibrators not mounted on top cover of power transformer and buffer condenser not to be mounted inside top cover of power transformer. The reason for this is obvious—it should not be necessary to dismantle a power transformer in order to replace a buffer condenser.

8. Wave-change switches to have shaft removeable from front of chassis in order to facilitate the replacement of a single faulty wafer.

9. Valve shields to be in one piece and shield base not to fit snugly round base of valve. This is in order that a valve which is tight in its socket may be removed by grasping the valve base instead of the glass.

10. Control knobs to have metal inserts (except push-on types).

It should be emphasised that the point aimed at is not necessarily the making of more reliable receivers, but rather how the construction could be modified to incorporate such points as the above, which would greatly assist servicemen and at the same time, cause him to sing the praises of the manufacturer!—I am, etc.,

J. W. STOKES.

* * *

Sir,—I desire to thank you for your excellent volume expander circuit published in the June issue of *Radio and Electronics*.

I fitted it to my amplifier and am more than satisfied with the results.

Like many others, I must confess that I was somewhat averse to trying it, but am very pleased I did. I would not hesitate to recommend it to anyone.

With many thanks and best wishes for a bigger and better *Radio and Electronics*.—I am,

JAS. MILLER.

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AERIALS FOR 10 METRES

While in no way pretending to be an exhaustive treatise on the subject, this article is intended to present the main types of aerial which can be used with success on the 30 m/sec. band. Some of the aerials will no doubt be familiar to amateur transmitters, but others will quite probably be new in the experience of many.

It is not intended here to go into great detail concerning the multitude of possible aerial arrangements, but merely to indicate some of the more useful types. Some of those presented are dealt with quite fully elsewhere, as, for example, in the A.R.R.L. Handbooks, and so will not be treated in detail here. However, for the sake of completeness, some mention must be made of the better-known types, if only for purposes of comparison.

REQUIREMENTS.

In discussing 10-metre aerials, it is necessary first of all to consider what requirements must be fulfilled. Some of these will apply equally to receiving or transmitting aerials, on account of the well-known reciprocal law, but some are determined solely by whether or not the aerial is to be used for transmitting.

First of all, a transmitting aerial must effectively radiate as much as possible of the power available in the final amplifier tank circuit. For receiving, the aerial must function as efficiently as possible and transfer the signal currents to the input terminals of the receiver with as little loss as possible. A little thought will show that these two requirements are really one and the same thing. For example, if an aerial radiates efficiently at its operating frequency, it must have been cut to correct length. In addition, the arrangements made to feed the power from the transmitter to the aerial must introduce a minimum of loss. This implies that impedances throughout the system have been properly matched, and that few losses exist owing to poor erection and the use of inefficient insulating material. All these conditions are exactly those which make for the delivery of the greatest signal to the receiver by a receiving aerial. It follows, therefore, that an efficient transmitting aerial makes the best receiving aerial for the same frequency.

The above applies equally to aerials used on any frequency, but, in general, the higher the frequency the more attention must be paid to all factors which might possibly introduce losses, so that on 10 metres considerably more trouble needs to be taken with an aerial installation to realise the efficiency which can readily be obtained, say, on 80 metres.

A requirement of 10-metres aerials which is not so apparent at lower frequencies is that, for best results, appreciable low-angle radiation must be secured. Fortunately, the mechanical and electrical features required are more easily attained on high frequencies than on low ones, so that it is a comparatively simple matter to secure low-angle radiation on 10 metres.

On any frequency, directional properties are highly desirable — first, because a directional aerial can lay down a much larger signal at the distant point for a given transmitter power, and secondly, because a directional receiving aerial can confer the advantage of greatly-reduced interference, both QRN and QRM. However, on frequencies below the 10-metre band, directional aerials are difficult to erect, on the score of the space required. But on 10 metres the wavelength is short enough to enable simple directional arrays to be built quite easily. It is thus possible to lay down the requirement that a 10-metre aerial should preferably be of the directional type.

SOME COMMON TYPES.

As at other frequencies, the half-wave doublet can be made a very efficient radiator or collector. On 10, however, due again to the short wavelength, the constructor has some measure of control over the pattern produced. Certainly, the half-wave doublet gives no more horizontal directivity than it does at other frequencies, but the vertical directivity may be quite easily controlled. For example, if a horizontal half-wave aerial is erected half a wavelength above ground, the vertical radiation pattern possesses only one lobe, with its maximum at an angle of elevation of 30 degrees. The lobe is not particularly narrow, and is effective at angles of approximately 15 to 45 degrees. At 10 metres, the required height is only 16 feet, which is easily attainable with the meanest sort of masts. If the height of the aerial is increased, two things happen to the vertical radiation pattern. First, the lobe drops to a lower angle of elevation. This is useful,

for it enables more power to be radiated at the lower angles, and consequently will give better long-distance working. Secondly, as the aerial is raised, a lobe appears close to the vertical. This represents power wasted for long-distance communication, for it will either be reflected to earth quite close to the transmitter, or, which is more likely in these latitudes, will penetrate the ionosphere altogether and be lost.

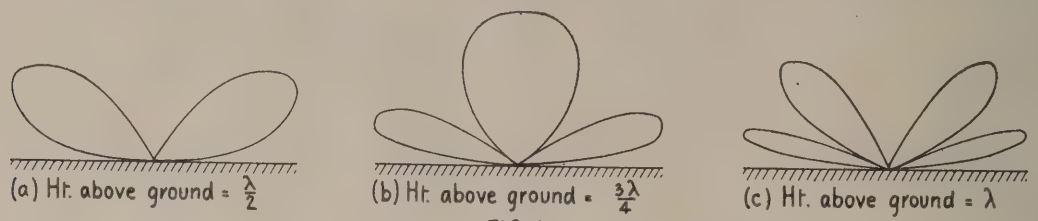


FIG. 1

It must not be assumed, however, that raising the aerial above half a wavelength will give decreased performance. The reason for this is quite easily seen from Fig. 1, which shows at (a) the vertical pattern of an aerial at a height of half a wavelength, and at (b) the same aerial at a height of $3\lambda/4$. The strength of the signal emitted in any direction is estimated on these figures by drawing a line from the point representing the position of the aerial, in the required direction. The relative signal strength is then measured by the length of this line intercepted by the curve of the lobe. Considering Fig. 1 in this light, it can be seen that, although there is considerable vertical radiation, the signal strength at the maximum of the low lobe is the same in Figs. 1 (a) and 1 (b). This means that, in spite of the vertical lobe, which is useless, we are still better off with the $3\lambda/4$ aerial than with the $\lambda/2$ one, because, without reducing the signal strength, we have concentrated some radiation at lower angles of elevation. This procedure definitely increases the DX performance of the aerial. Still lower angle radiation may be secured by increasing the height of the aerial to λ, which brings the main lobe down to about 12 degrees.

Further increases in height will not be worth while in terms of expenditure, because increasing height above one wavelength depresses the lower lobe only slightly for great increases in height. Thus, the practical limit is reached for 10 metres with a height of approximately 30 feet. Of course, many amateur transmitters have constructed rotatable arrays at heights greatly in excess of this and obtain excellent results, but the fact remains that at the greatly-reduced cost of a mast of only 30 feet in height, any deterioration in results would not be noticeable.

It should be remembered that the patterns in Fig. 1 refer only to horizontal aerials. The type of horizontal aerial has no effect on the vertical polar diagram, except when an array is used consisting of aerials stacked one above the other vertically. The patterns of Fig. 1 will be produced by a single horizontal dipole or by any of the popular arrangements using a radiator with directors and/or reflectors.

A commonly-used aerial at 10 metres is the vertical radiator. This has the advantage of producing low angle radiation whatever its height. Thus, if it can be erected in the clear, i.e., so that buildings or other obstructions do not lie in a desired propagation direction, there is no necessity to elevate it to any height at all. This is shown by the polar diagram of Fig. 2. Fig. 2 (a) is the pattern for a quarter wavelength vertical aerial mounted with its lower end at ground level. It can be seen that, in the vertical plane, radiation at very low angles as well as radiation at quite high angles is readily obtained. Fig. 2 (b) is for a vertical half-wave aerial also at ground level. This shows a considerable improvement over Fig. 2 (a), in that there is now very little radiation over 45 degrees. This means that the available power is being expended at the lower angles, so that, although the length of the lobe may not be greater than in Fig. 2 (a), the radiation at intermediate angles, say, from 15 to 25 degrees, is somewhat increased. It might be thought that still better performance could be obtained by increasing the length of the aerial still further, but this is not so.

Fig. 2 (c) shows what happens if a vertical aerial one wavelength long is used. The low angle radiation has almost disappeared, and we are left with a lobe, if anything, slightly worse than that given by a horizontal aerial half a wavelength high, the case of Fig. 1 (a). It should be

mentioned that the diagrams of Fig. 2 are a little idealised, for in actual practice a vertical aerial does not give maximum transmission at zero angle of elevation as Figs. 2 (a) and (b) would suggest. The reason for this is that the earth is not a perfect reflecting surface, and the slight losses which occur have the effect of producing a null at zero angle of elevation just as there is with a horizontal aerial. However, the bottom

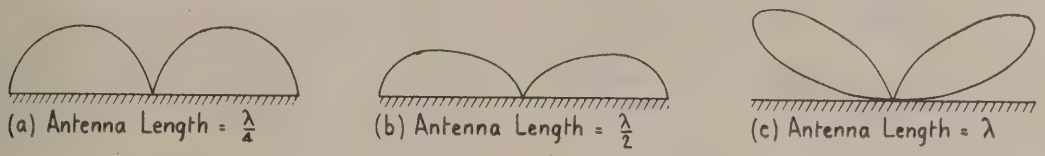


FIG. 2

edge of the lobe is quite low, and the loss of radiation at extremely low angles is unimportant because, in long-distance communication, angles of departure of less than five degrees are not required.

Fig. 3 shows three types of horizontal aerial very suitable for 10-metre working. At (a) is the ordinary delta-matched half-wave dipole. Although this one is, as it were, an "old-timer," it is by no means to be despised, for it is one of the most efficient ways of putting R.F. into the ether. The usual story that the delta-matched aerial is unsuitable for amateur use since it cannot be used on harmonics does not apply when 10 metres is under consideration, so that this form of aerial is perhaps more suited to 10 than to the other bands. The necessary information on the length of the section m and the distance for which the feeders should be fanned, can be found elsewhere in the amateur literature and

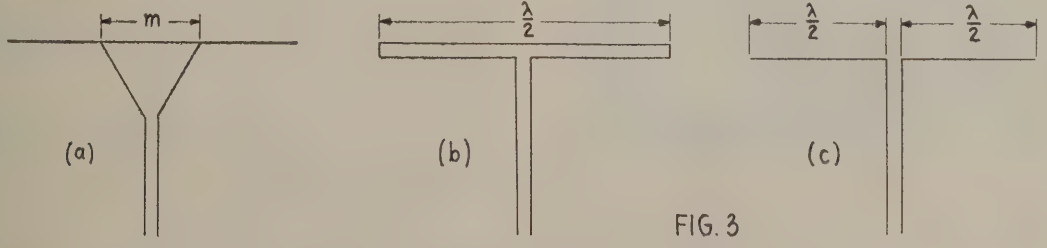


FIG. 3

so will not be given here. It should be emphasised at this point that all three aerials shown in Fig. 3 are suitable for use with non-resonant feeder lines, which are much superior to tuned lines on any frequency, but more so on 10 metres than on the lower frequency bands. For one thing, they radiate less and are therefore more efficient. Secondly, when properly matched to their aerial, they give an infallible indication of the latter's efficiency. For example, if it is known that the aerial matching is correct, by which we mean that (a) the aerial is cut correctly to length and (b) is correctly matched to the non-resonant feeders, there can be only one reason for difficulty in fully loading the final tank, and this is insufficient coupling to the latter.

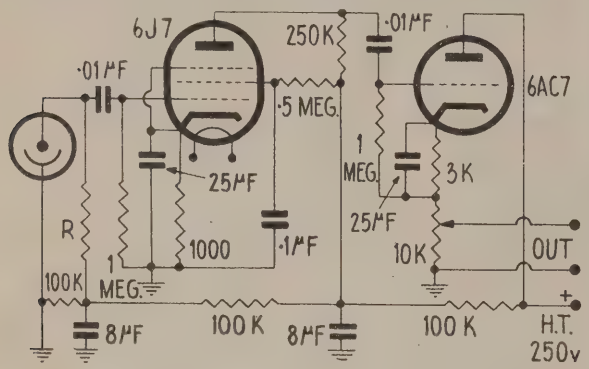
Again, if the aerial is cut to length, and no adjustment of coupling allows the final to be fully loaded, the only possible reason for this behaviour is that the feeders are not properly matched to the aerial. Thirdly, if the feeders are properly matched to the aerial and no coupling adjustment can be found which sufficiently loads the final, the only possible fault is that the aerial length is wrong. In short, using untuned feeders ensures that if the final is being properly loaded, the R.F. MUST be being radiated. There is no possibility, as with tuned feeders, that heavy losses in the feeder system are accounting for the R.F. being drawn from the tank. These advantages are very pronounced, especially in amateur work, because, with limited power available (frequently much less than the official 100 watts maximum plate input), it is obviously necessary to make sure that everything is going out if DX results are to be obtained.

Fig. 3 (b) is an aerial that may be new to some. It is a half-wavelength long, as usual, but an examination of the figure reveals that the wire is doubled back upon itself and brought to the centre, where the untuned feeders are attached. The advantage of this scheme, known as the folded dipole, is that the impedance obtained at the centre is of the order of 300 ohms, as against the 72 ohms found at the centre of the conventional dipole. This means that a 300-ohm

(*Continued on page* 46.)

QUESTIONS and ANSWERS

Mr. T. G. Kelly, Greytown, writes asking us to publish the circuit for a pre-amplifier suitable for use with a P.E. cell as the sound-head for converting a 35mm. silent projector for sound. He also asks what is the best way to couple the pre-amplifier to the main amplifier, which commences with a 6J7 voltage amplifier.



Circuit for the soundhead pre-amplifier. The load resistor R will be determined by the type of P.E. cell used.

We take pleasure in printing the accompanying circuit, which shows how the polarising voltage is derived from the main H.T. supply and applied to the P.E. cell. It is desirable to provide a separate power supply for the pre-amplifier if this is to be situated far from the main amplifier. If not, heater and H.T. voltages can be derived from the latter and should be run in shielded cable, preferably separate from the one carrying the signal. It is essential in any event to earth the pre-amplifier heater winding by means of a potentiometer across the 6J7 heater terminals on the valve socket. This is adjusted until hum is a minimum, and left set. If in the main amplifier, one side of the heater supply is earthed, this connection will have to be lifted. If a separate 6.3-volt winding is available, this should be used for the pre-amplifier alone.

The output coupling referred to in the question is via V_2, which is used as a cathode follower. The load has been shown variable so that volume control may be accomplished at the pre-amplifier, if desired, in which case the existing control on the main amplifier would be advanced to such a position that full output is obtained with the pre-amplifier control at maximum. This method of working the two volume controls ensures that the main amplifier is never over-loaded. We have not recommended any particular photo-electric cell type. Choice of a cell should not be difficult, and will be governed by the availability of suitable gas-filled cells.

* * *

Mr. H. J. Levey, of Takapuna, who is interested in DX reception on the broadcast band, writes asking whether we can advise him on the design of a receiver specially suited to his purpose. He suggests a superhet. with one R.F. stage, oscillator-mixer, and two stages of 175 kc/s. I.F. He also would like regeneration incorporated in the R.F. stage. Commenting on the average commercial receiver, he states that this is not nearly selective enough and also much too noisy for DX purposes.

Although we cannot give the circuit for such a set in this column, owing to restrictions of space, a few comments on Mr. Levey's ideas may be useful to those who, like him, find the ordinary set inadequate

The line-up suggested by Mr. Levey we consider an excellent one, with one or two reservations. First, regeneration in a superheterodyne is not good practice, because its beneficial effects tend to be cancelled by the need for constant and critical adjustment, particularly when it is in the R.F. stage as suggested. Besides, all that regeneration will do can be obtained by other means. Secondly, a debatable point is whether two stages of I.F. at 175kc/s are justified. Quite high selectivity can be obtained with only one stage at this frequency, and undoubtedly a single stage gives as much gain as can be used in ordinary circuits. However, in evolving a design, the two stages might well be retained on the score of extra selectivity, but throttled back to the point where the gain of the two stages is little greater than that of a single stage working "flat out."

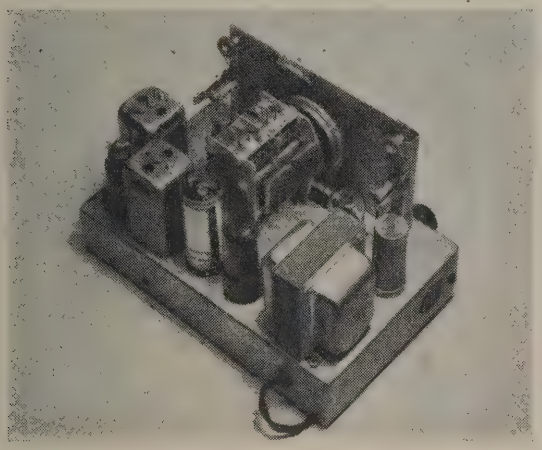
The mention of noise in Mr. Levey's letter opens up a wide field of endeavour for the would-be designer. Modern high gain tubes such as the 6AC7/1852 are not used in commercial broadcast receivers, but could find a place in a special design, with considerable advantage. For instance, this tube used in the R.F. stage instead of the conventional 6K7 or 6SK7 would give the receiver a greatly-improved signal to noise ratio. The latter is the all-important point in DX reception, and it should be emphasised as strongly as possible that overall gain plays only a minor part. This is because, as long as there is sufficient gain in a set to allow an easily readable output from the weakest desired signal, increasing the gain confers no advantages. The crux of the matter is the term "weakest desired signal." For, if the noise-level of the set itself is such that a two-microvolt signal is lost in the noise, there is no point in having a set which will give readable output from a one-microvolt signal—which would be even more unreadable. If, however, a reduction of a half can be made in the set noise-level, then a usable gain of twice the original is practicable. **In short, extra gain in a receiver will produce extra signals only if an improved signal-to-noise ratio is obtained at the same time.** In the design of a receiver, gain may be acquired easily, but improved signal-to-noise ratio is quite difficult to achieve. In spite of this, the use of modern circuits applied to a broadcast receiver can undoubtedly improve the signal-to-noise ratio by at least 10 Db. In the case of ordinary broadcast sets, this is not done, because for normal listening purposes it is quite unnecessary. It is the intention of "Radio and Electronics," if interest among DX-ers is sufficiently great, to publish the design of a receiver which will fully meet Mr. Levey's requirements, and which, by virtue of advanced design, impossible to the manufacturer building thousands of sets a year, will outperform by a very long way anything in normal use for broadcast DX purposes in this country to-day.

THE RADEL A.C. DUAL-WAVE FIVE

The Radel A.C. Broadcast Five was accorded so enthusiastic a reception two months ago that the editors of "Radio and Electronics" have decided to carry on with a series of domestic set designs suitable for the home builder. This article presents the dual-wave counterpart of the Broadcast Five, and should meet the need for an inexpensive dual-wave receiver with good performance within its class.

CHASSIS LAYOUT.

The layout of this set follows exactly that of the Broadcast Five, except in minor details. In the latter, there were, of course, only three control knobs, and the tuning control was mounted directly under the dial.

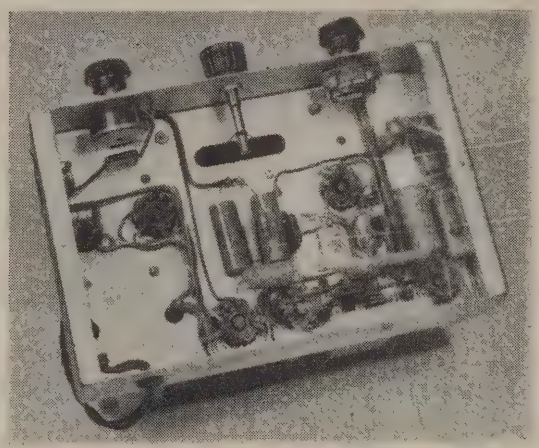


The completed Radel Dual-wave Five. Note the similarity in appearance to the Broadcast Receiver.

With the string-drive type of dial, the placement of the knob can be altered quite easily, as the only change necessitated in the chassis is to shift the cut-out, which allows the string to pass through. The complete chassis is shown in Fig. 2, which gives the position for all the large holes for the valves, speaker plug, and the dual electrolytic condenser. The power transformer is mounted at the back left-hand corner of the chassis in the space provided. Reading to the right along the back of the chassis, the first valve-hole is for the 6V6 output tube. The one just beside it is for the 6Q7 second detector, A.V.C. and first audio tube. Then comes space for the second I.F. transformer, and in the right-hand back corner the socket-hole for the 6K7 I.F. amplifier tube. Directly in front of this is space for the first I.F. transformer, close to the 6K8 socket. To the left of this, in the centre of the chassis, is mounted the gang condenser. To the left again are the socket-hole for the 6X5 rectifier and the $\frac{3}{4}$in. hole for mounting the dual 10μf. electrolytic smoothing condenser. A photograph of the completed set is given, and from the top it can be seen that the set has exactly the same appearance as the Broadcast Five. Referring again to the dimensioned chassis diagram, the holes along the front of the chassis are for the following controls. At the left is the tone-control, after which come the tuning-control, the wave-change switch, and the volume-control.

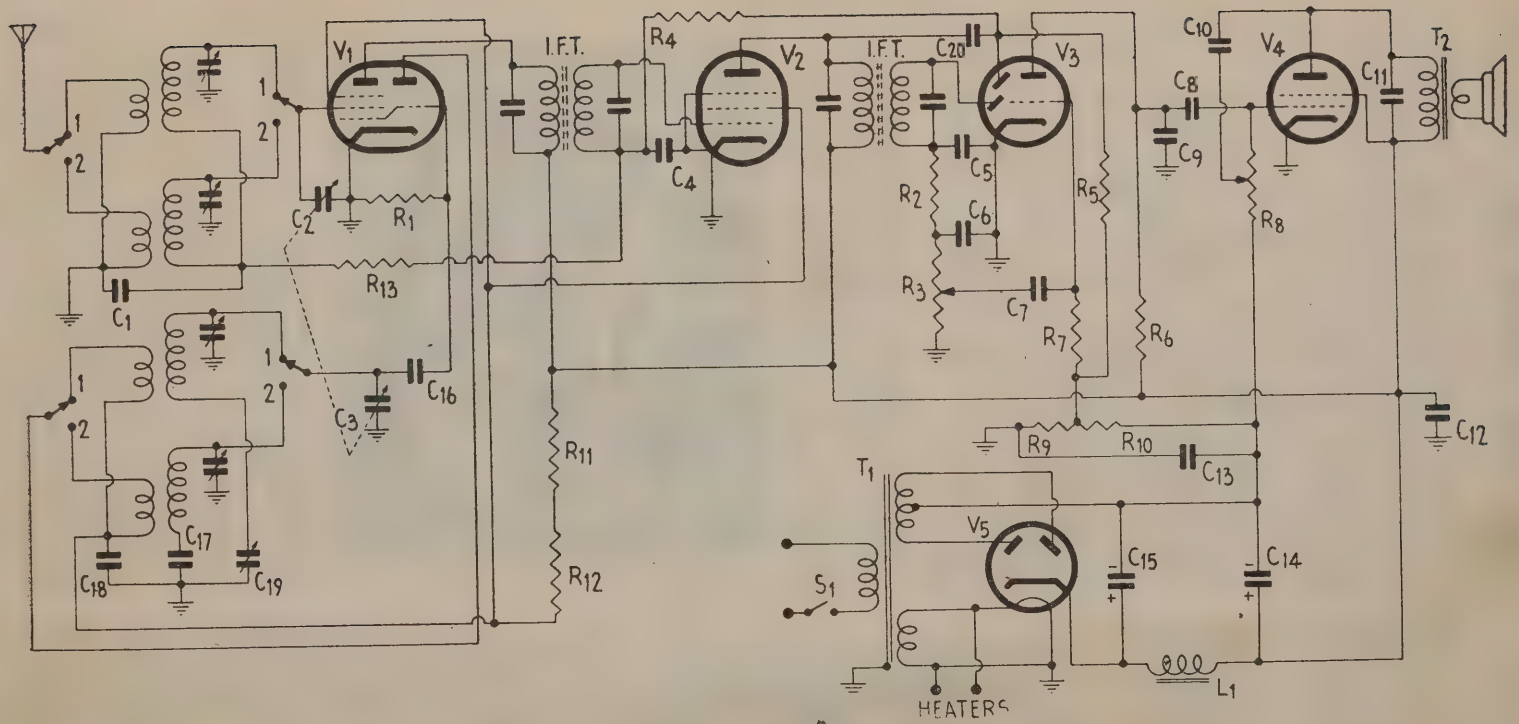
UNDER-CHASSIS ARRANGEMENT.

If reference is made to the under-chassis photograph of the Broadcast Five, it will be noted that there is plenty of free space near the



Underneath view of the Broadcast Five, showing space available for mounting the extra components used in the dual-wave version.

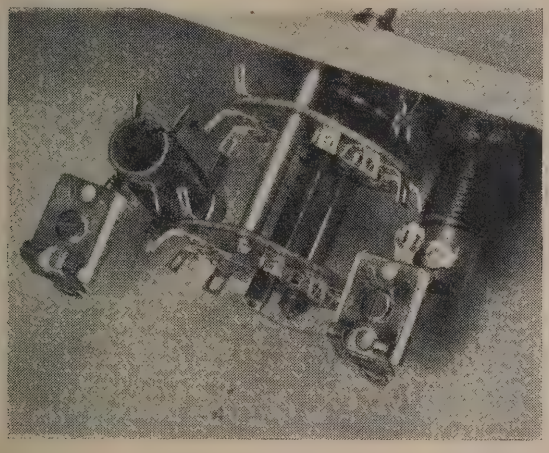
front of the chassis for mounting the wave-change switch and the shortwave coils. The second photograph reproduced here indicates the arrangement that should be used for mounting the latter. It was taken before the prototype of the dual-wave version was wired up, and shows the aerial coil mounted horizontally as close as possible to the switch. The oscillator coil



COMPONENT LIST.

C_1, C_{12}, C_{18} = 0.05μf.
C_2, C_3 = Ganged tuning condensers.
C_4 = 0.1μf.
C_5, C_6, C_9, C_{16}, C_{19}, C_{20} = 0.0001μf.
C_7, C_8, = 0.01μf.
C_{10} = 0.00025μf.
C_{11} = 0.005μf.
C_{13} = 25μf. 25v. Electro.
C_{14}, C_{15} = Dual 10μf. Electro.
C_{17} = 0.004μf.
R_1, R_2 = 50k.
R_3, R_8 = 500k. pot.
R_4, R_5, R_7 = 1 meg.
R_{13} = 100k.
R_9 = 165 ohms.
R_{10} = 35 ohms.
R_{11}, R_{12} = 5k.
T_1 = Power transformer 320v.-a-side, single 6.3v. heater winding.
S_1 = On/Off switch.
L_1 = 1500-ohm speaker field winding.
V_1 = 6K8.
V_2 = 6K7.
V_3 = 6Q7.
V_4 = 6V6.
V_5 = 6X5.
I.F.T. = 465 kc/s. iron cored.
T_2 = Output transformer.

is mounted vertically beside the switch, and the trimmer condensers for the shortwave band can be seen mounted on the terminal lugs of the coils, ready to be wired up. The broadcast coils can be mounted in the same positions as were used in the Broadcast Five, and leads from them taken to the switch, instead of directly to the gang, etc.



Showing how the shortwave coils and wave-change switch are mounted before wiring them up.

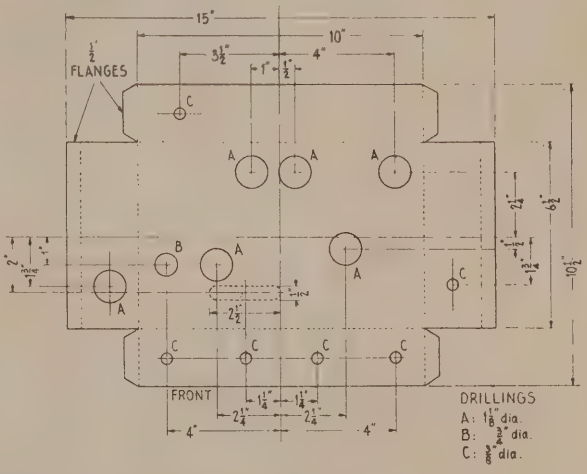
The question of broadcast trimmers now appears, because, in the set for broadcast only, these are mounted on the gang condenser and are an integral part of it. The gang for a dual-wave set, however, should not have trimmers, because both bands have to be adjusted separately. Thus, the broadcast coils in this set are provided with their own trimmers, which should be mounted on the coil terminal lugs, exactly as for the shortwave ones illustrated. The padder for the shortwave range is fixed, and so can be wired in as close to the coil as possible. The padder for the broadcast band should be mounted on the chassis alongside the broadcast oscillator coil, exactly as was done in the Broadcast Five.

THE CIRCUIT.

The tube line-up is the same as for the broadcast version and is as follows: 6K8 or 6A8 oscillator-mixer, 6K7 I.F., 6Q7 second detector, A.V.C. and first audio, 6V6-GT output, and 6X5-GT rectifier.

Apart from the addition of the shortwave range, there are a few circuit changes. The method of tone control is the same as before, and the same method of A.V.C. diode feed is used. The only important changes are in the method of obtaining bias for the valves, and the use of dropping resistors for obtaining the oscillator plate voltage and the screen voltage for the 6K8 and 6K7. As far as performance is concerned, there is nothing to choose between the two bias methods, so that the more advanced constructor may use the bias circuit given in the Broadcast Five if he prefers this. The present circuit dispenses with cathode resistors and by-pass condensers, and uses instead a tapped 200-ohm resistor connected between ground and the centre-tap of the high-voltage winding on the power transformer. Examination of this circuit will show that the plate current of all tubes flows through this resistor in such a direction that the unearthed end is negative. The resistor thus acts as a supply of negative bias.

The full bias is applied to the 6V6 by connecting its grid return directly to the "high" end of the 200-ohm bias resistor. The tap is connected through the A.V.C. bias to the grids of the 6K7 and 6K8, while the 6Q7 obtains its bias directly from the tap. It is important to adjust



the position of the slider to the correct point before first switching on the set. This can be done with the aid of an ohm-meter. If such an instrument is not available, a low-range voltmeter may be used in the following manner: Set the slider about a quarter of the way along from the earthed end. Turn the set on and, after allowing about two minutes for it to warm up, measure the voltage from tap to earth. If it is higher than three volts, slide it towards the earthed end until a reading of three volts is obtained. *The slider should not be adjusted while the power is on.*

A voltage of approximately 100 is obtained for the oscillator plate and the screens of the

R.F. tubes, through R_{11} and R_{12}. The idea of using two resistors in series is to obtain a single 10,000-ohm resistance of two watts rating using only one-watt components.

The second detector circuit is slightly different from that used in the Broadcast Five in that an extra resistance and condenser, R_2 and C_5, are used to prevent R.F. from getting into the audio stages. The combination shown is somewhat more effective in this respect than the circuit used in the Broadcast Five.

WIRING.

If the layout suggested is followed, the wiring will automatically fall into place on the chassis. The only point which requires special consideration is the wiring of the shortwave coils to the wave-change switch and the wiring from the latter to the gang condenser and the 6K8. This should be done in heavy bare tinned copper wire. Using this is important if the shortwave band is to perform at maximum efficiency, for ordinary push-back introduces severe losses at the higher frequencies, and also causes oscillator drift, which is very annoying, as it causes shortwave stations to drift off tune as the set warms up. Using bare wire will not eliminate it altogether, but removes one of the most potent causes of this undesirable characteristic. Since solid wire is used, there will be no tendency for short circuits to develop, since once the wires are in position they will not shift.

LINING-UP.

The set is no more difficult to align than is the broadcast version. The I.F. transformers should be peaked up first, starting with the trimmer of the winding feeding the diode detector, and working backwards to the trimmer in the plate circuit of the 6K8. This done, the broadcast band should be aligned. The procedure is exactly as outlined in the July issue of *Radio and Electronics* for the Broadcast Five, except for the fact that this time, the trimmers are attached directly to the broadcast coils instead of being mounted on the gang condenser. Lining up the shortwave band is simpler than the procedure used for the broadcast band, since in this case the padder is fixed. All that has to be done is to find a setting for the oscillator trimmer, with the gang condenser almost unmeshed, that will allow a peak response to be obtained when adjusting the shortwave aerial trimmer.

It is only to be expected that as accurate alignment will not be obtained on the shortwave band as on broadcast, particularly with a set of this nature not provided with an R.F. stage. The reason for this is that connecting the aerial can have a serious effect on the tuning of the shortwave first detector coil. For this reason, alignment on shortwave should be undertaken with the actual aerial connected. Even so, it may be found that some part of the shortwave band is not as sensitive as the rest. For instance, if one is interested mainly in the reception on the 31-metre band, it might be advisable to adjust the aerial trimmer with the set tuned to this band rather than to the 19-metre band at the high-frequency end of the scale. It is quite easy to find a compromise adjustment of the trimmer which will give reasonable results all over the dial rather than good results at the high-frequency end only, but the normal method of lining up should be tried first, since coils are designed to track when lined up in this manner.

PURCHASING PARTS.

In our article on the Broadcast Five, we gave some hints on the purchasing of alternative parts should those specified not be available. The same remarks apply equally well here, except for one case. The 6K8 is a much better performer on shortwave than is the 6A8, and should be used at all costs in the dual-wave set. Practically all coils manufactured to-day are designed for the former type, so that little difficulty should be experienced. In particular, make sure that the coils purchased are designed for the type of gang condenser which you buy. Although the effect on the broadcast band may not be serious if the wrong condenser is used, tracking and general performance on shortwave will be seriously impaired.

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THE APPLICATION OF MINIATURE TUBES

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This Note presents information on the miniature tube types 1R5, 1S4, 1S5, and 1T4. These tubes can be operated from a 45-volt B-battery and a 1½-volt A-battery. The size of these tubes, in cubic inches of volume, is only about one-fifth that of the 1.4-volt GT tubes. The new tubes are, therefore, well suited for use in wearable hearing aids, meteorological balloons, pocket-size receivers, other portable receivers or any radio equipment where small size and light weight are important. This Note is concerned principally with the use of miniature tubes in receivers and especially with the operation of the 1R5 pentagrid converter.

The small size of the miniature tubes is principally due to a new tube structure which eliminates the conventional base. The base of the miniature tubes is a glass button sealed to the bulb. Running through this button are seven stiff wire stubs which serve as electrode supports inside the tube and base pins outside the tube. The electrode assembly is only about ¼ inch above the base. This compact structure makes it possible to mount a full-size 1.4-volt filament in a tube only 2⅛ inches long.

In addition to their small size and low B-voltage requirement, the miniature tubes have other important advantages. The 1R5 pentagrid converter employs an oscillator circuit which inherently gives high oscillator transconductance. Both the 1R5 converter and 1T4 I.F. amplifier have a remote cut-off characteristic which enables them to handle a wide range of signal strengths without modulation distortion. The 1S5 diode-detector and A.F. amplifier tube has a pentode amplifier section which can provide an audio gain of 30 when B-supply is 45 volts, and adequate signal output when the B-battery is at the end of its life. The 1S4 output tube has a maximum-signal power output of 65 milliwatts when plate and screen voltage are 45 volts, and 190 milliwatts when plate and screen voltage are 67.5 volts. All the miniature types have a single-ended construction which eliminates flexible grid leads and top-cap connectors.

Circuits for the 1R5 Pentagrid Converter

The 1R5 is a pentagrid converter similar to the 6SA7 in that the 1R5 has no separate oscillator anode. Typical circuits for the 1R5 are shown in Fig. 1. In Circuit I, oscillator feedback is provided by making plate and screen current flow through a tickler coil. In Circuit II, oscillator feedback is provided by connecting the filament to a tap on the oscillator tank coil.

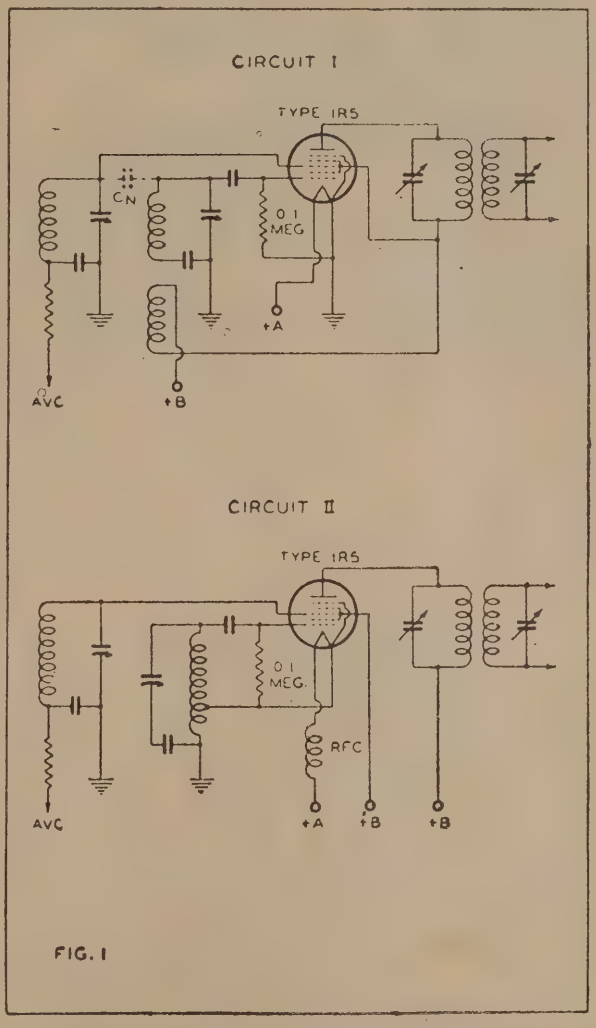


FIG. 1

This second circuit is similar to the cathode feedback circuit used with the 6SA7.

In both circuits, the 1R5 has two important advantages in addition to the fact that the B-supply can be as low as 45 volts. One advantage is that, in both circuits, almost all the electron current emitted by the filament is effective in providing feedback. As a result, the oscillator transconductance of the 1R5 in the circuits of Fig. 1 is higher than that of other battery-operated converter types in the conventional circuit where the feedback current (the oscillator-anode current) is only about 50 per cent. of the total emission current. The high oscillator transconductance of the 1R5 makes it possible to obtain wider tuning ranges with this tube.

A second advantage of the 1R5 is due to the fact that the arrangement of grid side-rods in the 1R5 is similar to that in the 6SA7. Because of this arrangement, most of the electrons turned back toward the filament by the negative signal grid are prevented from reaching the space charge near the filament. This action of the side-rods, together with the electrostatic shielding of the screen, practically isolates the filament space charge from the signal grid. As a result, changes in signal-grid bias produce very little change in oscillator transconductance. Changes in A.V.C. bias, therefore, produce very little change in oscillator frequency. This feature of the 1R5 is important in short-wave operation.

Comparison of Circuits I and II.

In a receiver which is to use the 1R5, the choice between Circuits I and II depends on the frequency range of the receiver. In a set tuning not higher than about 6 megacycles, Circuit I is generally preferable. In a set which is to tune higher than this frequency, Circuit II might be preferable. At the high frequencies, the choice between the two circuits depends on the following considerations.

Circuit I has the advantage that it is somewhat easier to provide adequate grid excitation in a tickler-feedback oscillator than in a cathode-feedback oscillator. When Circuit I is operated at frequencies higher than about 6 megacycles, a neutralising condenser C_N should be connected in the circuit, as discussed in the next paragraph. Circuit II has the advantage that it does not require this neutralisation. Also, band-switching in Circuit II may be simpler than in Circuit I. The relative importance of these advantages will determine the choice between the two circuits for use in a particular receiver operating at high frequencies.

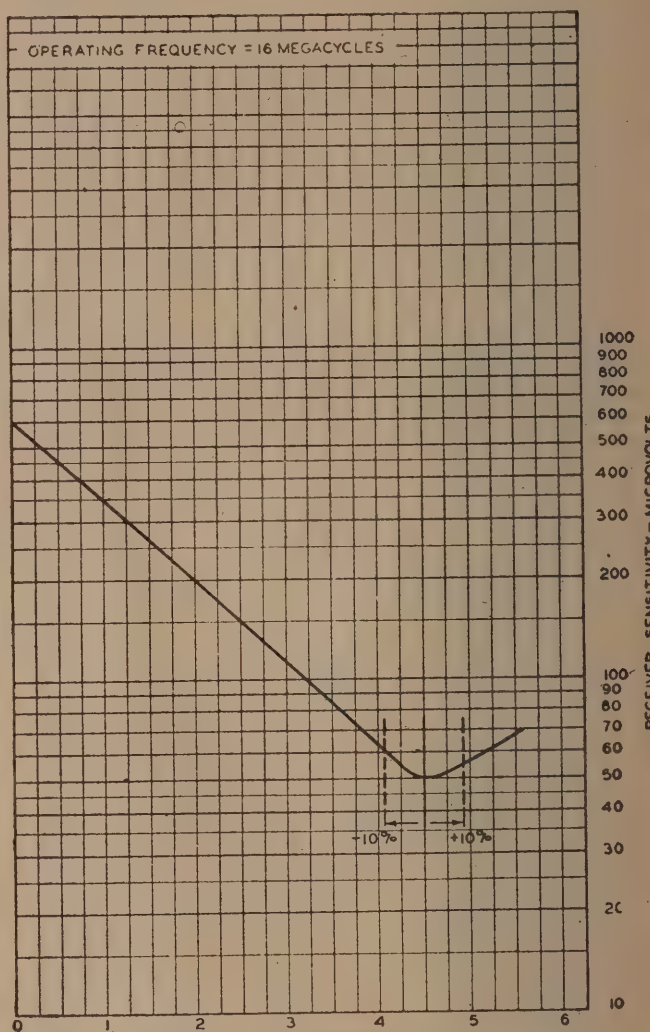


FIG. 2

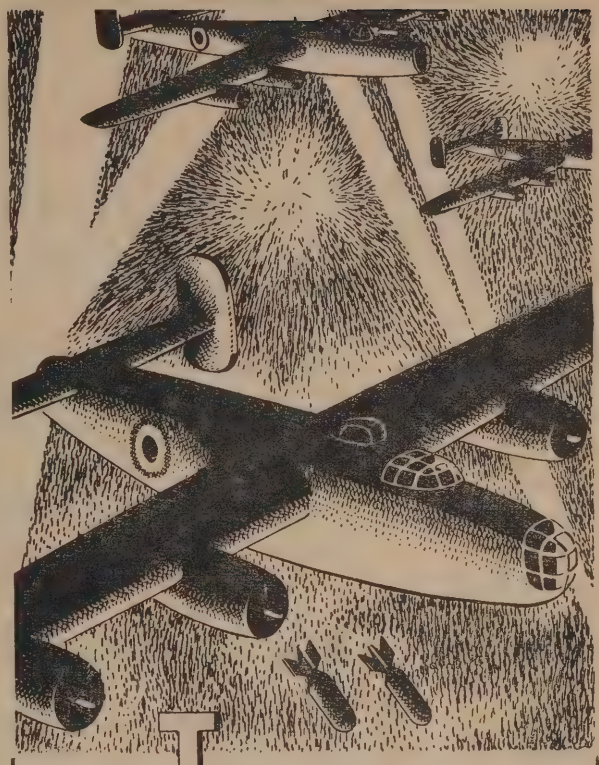
Neutralisation of Circuit I.

In operation of Circuit I at frequencies above 6 megacycles, the oscillator voltage on the screen may cause considerable oscillator voltage to appear on the signal-grid. The reason is that, at these frequencies, there is only a small percentage difference between the signal and oscillator frequencies. The impedance of the signal-grid circuit at oscillator frequency is therefore appreciable compared

with that of the screen-to-signal-grid capacitance. To minimise the oscillator voltage on the signal-grid, a small condenser should be connected between the signal-grid and the No. 1 grid, as indicated in dotted lines in Fig. 1, when Circuit I is to be tuned higher than 6 megacycles. Because the oscillator voltage on the No. 1 grid is in phase opposition to that on the screen, the oscillator voltage on the signal-grid can be practically cancelled by use of the proper capacitance for C_N.

The effect on receiver sensitivity of variation in the capacitance of C_N is indicated by Fig. 2. This curve was plotted for a typical receiver operating at 16 megacycles. The values on this curve are not necessarily correct for other receivers, but the curve shape is approximately correct for other receivers. The explanation of this curve shape is briefly as follows: There are two components of oscillator voltage on the signal-grid, one applied from the No. 1 grid, the other applied from the screen. The two components are in phase opposition. In the receiver for which the curve of Fig. 2 was plotted, when C_N is approximately equal to 4.5 $\mu\mu f$, the two components are equal, and cancel each other. When C_N is smaller than 4.5 $\mu\mu f$, the net resultant oscillator voltage on the signal-grid is in phase with the screen voltage and out of phase with the No. 1-grid voltage. As a result, the oscillator voltage on the signal-grid reduces the modulation of the electron stream by the No. 1 grid and, therefore, reduces conversion transconductance. When C_N is larger than 4.5$\mu\mu f$, the net resultant oscillator voltage on the signal-grid is in phase with the No. 1-grid voltage. This in-phase voltage on the signal-grid increases plate current above the value giving maximum conversion transconductance, and causes the d-c current to the signal-grid to become comparatively large. This grid current loads the signal-grid tuned circuit and increases the A.V.C. bias voltage on the I.F. tube. From this explanation it can be understood why there is a value of C_N giving maximum sensitivity. However, the value of C_N is not critical; it can be seen from Fig. 2 that variations of ± 10 per cent. in C_N do not cause excessive variation in the sensitivity of the receiver measured. In other receivers, it has been found that variations of ± 20 per cent., or even more, can be tolerated.

(To be concluded.)



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ELECTRONICS— WHAT IT IS AND WHAT IT DOES

By L. J. A. van Lieshout, Philips Radio Works, Eindhoven.

The comparatively new science of electronics is destined to become a powerful servant of mankind. Its applications to industry and to everyday living are almost limitless, and it may safely be said that the marvels it accomplishes to-day will seem utterly commonplace to-morrow.

Our purpose here is to strip electronics of some of its mystery—to explain what it is and what it does; in short, to show its relation to your personal life and the influence it will have on future living conditions.

Electrons can be controlled easily because they move more or less freely through copper wire and other conductors, but not through insulators, such as glass and rubber. Forcing electrons through resistive metals generates heat, making possible the action of your toaster or flat-iron. Or in a bulb from which most of the air has been removed, they heat a wire to incandescence and thus light your home.

When electrons are pushed through wires wound in the shape of a coil, they set up a field of magnetic force. This electro-magnetic force is the kind used to rotate electric motors.

Electrons can be made to flow in one direction (direct current) or to alternate in opposite directions (alternating current). In alternating current, each reversal of direction is called a "cycle," and the number of reversals in a given time is termed a "frequency."

The range from below 60 up to 16,000 cycles per second in the electro-magnetic "spectrum" covers the field of audible sound reproduction. A microphone picks up your voice and converts it into small electron currents, which are amplified by electronic tubes. These tubes are small powerhouses filled with electrons "raring to go," and only a small electric variation on their control grid is needed to produce amplified power instantly. Compare this action to the foot pressure exerted on the accelerator of a car and its result.

Amplified speech can be carved mechanically on a wax plate or, by electro-magnetic induction, "frozen" into the atoms of a steel wire. These are the principles of the phonograph and magnetic wire recording. To reproduce the sound on your record made from the wax master-plate, you use a pick-up, which changes mechanical movement into electrical currents. To reproduce the sounds of a wire recorder, the magnetised steel wire runs through a coil and induces electrical currents therein.

In talkies, the sound that goes with the action is recorded by a photographic method in which the amplified sounds activate a shutter which intercepts a beam of light. These light variations are photographed on the sound-track of the film. To reconvert them into electric currents, a photo-electric cell tube is used. This tube converts light into electricity; more current for more light and less current for less light. It will convert into electric currents the whispered words of many a film love or the roar of a train, to be heard through the loudspeakers of your movie theatre, and the performance is enhanced by a mercury-vapour lamp that equals the surface brightness of the sun.

In a large railway station a photocell device opens the doors of the waiting-room for you. Without knowing it, you intercept a beam of light which "triggers" the photocell door-opener.

You might not suspect that homogenised, pasteurised, or "pepised" milk came in close contact with another offshoot of electronics, namely, supersonics. That is what sound vibrations are called when they go beyond human hearing, i.e., higher than 16,000 cycles a second. Supersonics are actually sound waves generated by electronic vibrations in a sound-producing device similar to a loudspeaker. They go as high as 500,000 cycles a second, killing bacteria by their violent vibration. Thus they are used to pasteurise milk. The milk retains more of its original qualities than when pasteurised by heat.

Hand or face lotions and similar emulsions do not have to be shaken before using because supersonics did it for keeps during manufacture and far better than you ever could. Many a chemical process is accelerated, sulfa drugs made more effective, shell casings inspected, ships guided into harbours, and submarines located by

supersonics. Japanese beetles can be kept away from shrubbery and fruit trees and drinking water in reservoirs kept free from seagulls because supersonic waves are very annoying to such insects and birds.

At higher frequencies we find electrons move either with the help of conductors or right through space, as radio broadcasts do. Quite a number of radio stations radiate up to 50,000 watts of electrical energy—the equivalent of some 70 horse-power—on frequencies from 550,000 cycles to well above 20,000,000 cycles. The lower frequencies which you find on your radio dial are for local use, while the higher ones serve for medium distance and worldwide coverage. With the help of a photocell at the transmitter, translating light and dark into electrical impulses, and an electrically-controlled "fountain-pen" at the receiver, news photos are transmitted from continent to continent.

Your fruit juice might well have come from a container soldered with "radio-heat." You can glue plywood sheets together in minutes instead of hours by applying radio-heat—at a frequency of around 15,000,000 cycles. The manufacture of penicillin is speeded and the flow and quality of plastics are improved by radio-heat.

Radiated at around 50,000,000 cycles, electrons move in almost straight lines like light. They cover, therefore, only a small area. You'll find television in this part of the spectrum. It is just another combination of photocell action and radio technique. In the television studio a "pick-up tube" is focused on the scene to be televised. Inside the pick-up tube are thousands of miniature photocells that capture the light reflected by the scene to be televised, and convert this light into minute electrical currents. These electrical currents are released, one after another, with the aid of a scanning device, instantly amplified and broadcast.

At the receiving end the scene is reconstructed by a special tube called a cathode-ray tube. In a cathode-ray tube a sharp beam of electrons is shot by an electron gun at a fluorescent screen of a diameter varying from 5 to 20 inches. During television reception, auxiliary currents guide this electron beam to the correct position on the screen, which lights up only at the point where the electrons hit. In this way the scene is built up, bit by bit, in exactly the same sequence as the "scanning" is done in the pick-up tube at the studio. By presenting 30 images a second, smooth, flowing movement is seen on the screen. With the use of special lenses an enlarged picture can be projected, making television as entertaining as a home movie show. Black-and-white television requires only one scanning for each image, but colour television needs three. The first scanning releases the red, the second the yellow, and the third the blue light components of a scene to be televised. Combination colours are then separated into their primary components; green, for instance, into yellow and blue. Your impression of a green picture at the receiver is then created by flashing quickly, one after another, its yellow and blue components, coloured by a rotating colour disc placed in front of the cathode-ray tube.

Electronic radiation on very high frequency bounces back from buildings, bridges, and similar structures—the now well-known radar. We use this electronic echo to detect planes and ships when they are still out of sight or hearing range. These same very high frequencies are used to guide commercial air traffic around the country and help pilots to land planes safely when the airfields are shrouded in fog.

By using a specially-developed high-frequency cable, hundreds of telephone conversations can be handled at the same time between two large cities, for instance, where formerly hundreds of wires were needed. Later developments indicate that such telephone traffic can also be handled by low-powered radio stations, working in relay on very high frequencies and placed approximately 35 miles apart. With higher frequencies, smaller components are used. So "walkie-talkies" and "handy-talkies" became possible. Similar developments will give you, in the future, your own "talkie-homie" in your car.

Higher than the highest radio frequencies, but just lower than visible light, is the invisible infra-red portion of the electro-magnetic spectrum. It is produced in filament type lamps that also give some visible light. You observe the infra-red radiation more as warmth than as light, because it has the pleasant characteristic of causing heat upon impact. The greater the mass, the more heat; so when infra-red strikes a freshly-painted automobile, it will dry the paint from the inside out rapidly because the metal heats faster than the paint. As there is no need to heat a bulky oven, infra-red is very economical. An industrial tool of no small importance, it dehydrates, anneals, and pre-heats a great variety of products at low cost and is slated for even more important uses in the future.

The division of the electro-magnetic spectrum that follows infra-red is an electronic radiation called light, for which you have the antennae right in your head—your eyes.

Visible light creates a photo-chemical reaction in your eyes which you experience as sight. Fluorescent lamps stand out here as major developments of the gas-filled electronic discharge tube. Their light is caused by the impact of electrical charges, increased by violent collisions between electrons and gas atoms, on the fluorescent powder, covering the inside of the glass tubes.

Still higher in frequency than visible light is the ultra-violet portion of the electro-magnetic spectrum. A part of it is responsible for your suntan, another tenderises meat, kills bacteria, and shows up false pearls. By the name of "black light"—because it is invisible—it mystifies many a theatre audience, revealing people moving about on the stage without head or legs. This effect is obtained by treating with fluorescent materials only those parts of the costumes that are to be visible.

X-rays partly overlap and follow the ultra-violet. More dangerous to the layman than ultra-violet, they render valuable service to mankind both in therapy and diagnostics. Being electronic vibrations resulting from bombardment of electrons against a metal target placed in high vacuum, they pass easily between the atoms of matter. Depending on the density of the atomic structure of such matter, X-rays are more or less absorbed so that human tissues and bone, for instance, show up on X-ray photos or fluorescent screens as shadows of different degrees of blackness. These penetrating rays also help to inspect metals for internal flaws, align spark plugs, detect foreign substances in foods, etc.

A special technique uses the reflection of X-rays caused by the atoms in the crystal structure of materials. Known as X-ray diffraction, this technique makes accurate analysis of materials faster and surer. High voltage is essential for the generation of X-rays; the higher the voltage, the shorter the wavelength, the more penetrating they become. With 2,000,000 volts, photography through 12 inches of steel plate has been possible, revealing cracks or impurities. In this way the efficiency of many a major weapon of war and product of peace has been substantially increased. (*Concluded on page* 48.)

DESIGN SHEET No. 2

Volts, Milliamps, Ohms, and Watts.

Several of the most frequently used calculations in radio work are those dependent upon Ohm's Law and upon the relationship between E.M.F. current and power. The two equations involved are:—

$$I = \frac{E}{R} \text{ and } W = IE = I^2R = \frac{E^2}{R}$$

In these equations, I is in amperes, E in volts, R in ohms, and W in watts. Eight different calculations can be made from these two equations, because if any two of the quantities in either equation are known, the third can be found. Following is a list of these calculations:—

(1) Current may be found knowing the voltage across a resistor and the value of the resistor.
(2) The voltage across a resistor may be found knowing its value and the current flowing through it.
(3) The resistance of a component may be found knowing the voltage across it and the current through it.

These three are from the first equation, that of Ohm's Law.

(4) The watts dissipated in a resistor when the current through it and the voltage across it are known.
(5) The watts dissipated in a resistor when the current through it and its value are known.
(6) The watts dissipated in a resistor when the voltage across it and its value are known.
(7) The current through a resistor when its value and the watts dissipated by it are known.
(8) The voltage across a resistor when its value and the watts dissipated by it are known.

Design Sheet No. 2 gives a quick method of working out any or all of these eight calculations. Only three scales are used in any one calculation. For instance if we are given the fact that there are 40 volts across a resistor of 100 ohms, a ruler is laid across the abacus so as to touch these two values on the scales. Reference to the point where the ruler cuts the milliamps scale gives us the current through the resistor. In addition, where the ruler cuts the watts scale gives the dissipation in the resistor. In the case cited, the current is 400 milliamps, but the dissipation cannot be read from the abacus as the answer is off the scale. It can be seen that the range of values covered is limited, because it is not possible to put longer scales in the space on the page, but calculations may be effected involving volts from 1 to 500, ohms from 0.1 ohm to 10 megohms,

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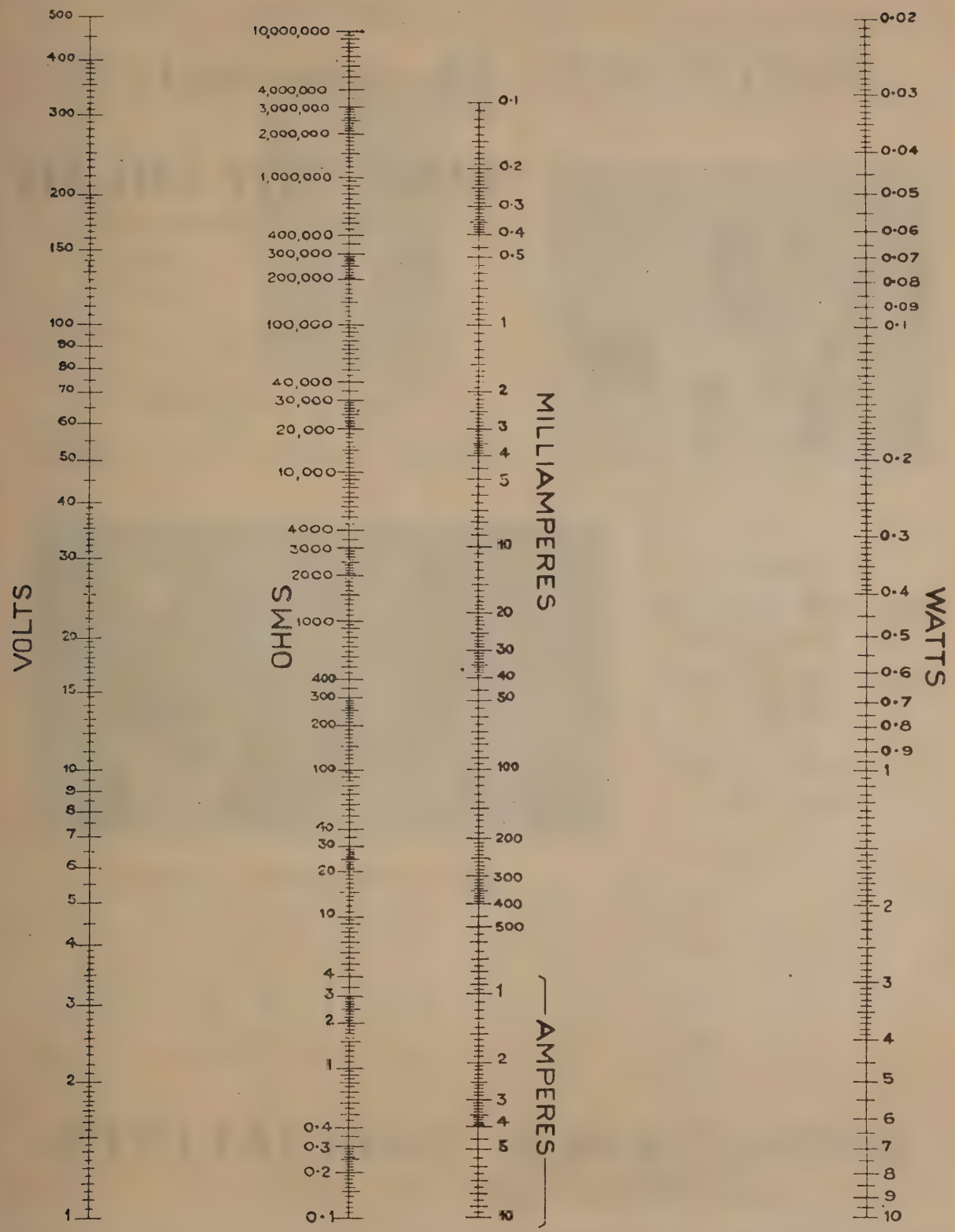
current from 0.1 milliamps to 10 amperes, and watts from 0.02 to 10.


VOLTS
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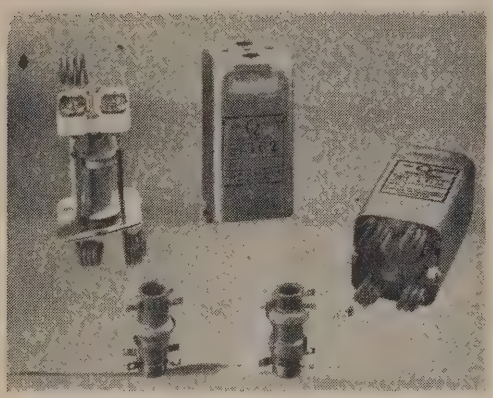
INDUCTANCE SPECIALISTS



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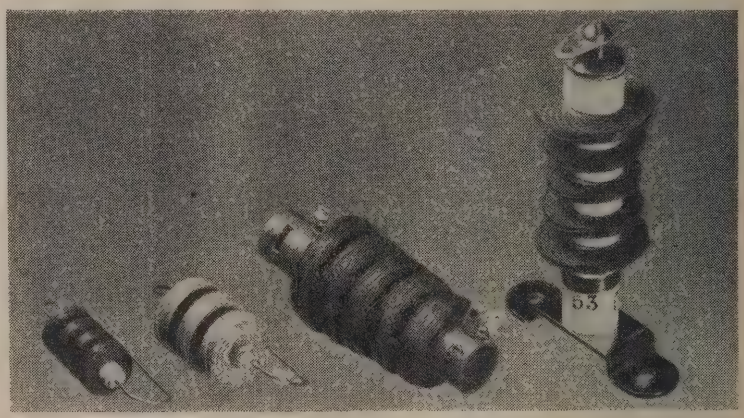

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(Illustrated from left to right.)

No.	Inductance	Rating	Resist.	Former	Mounting	Pyes	Dis. Cap
33	2.5MH	125MA.	35.0 ohms D.C.	Ceramic	Pigtail	4	1mmF.
23	1.0MH	300MA.	10.0 ohms D.C.	Ceramic	Pigtail	3	1mmF.
43	4.0MH	600MA.	10.0 ohms D.C.	Ceramic	Vertical	5	—
53	1.0MH	600MA.	6.0 ohms D.C.	Ceramic	Vertical	5	—

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Since the death of Keith Wrigley, George has been closely associated with Akrad Radio Corporation. His knowledge of production matters has been of great assistance in this direction.

The Akrad Corporation has made a new departure in the manufacturing field and is producing "Flyer" tricycles. These are being distributed by G. A. Wooller, Ltd.

Although he devoted a good deal of time to sport in the past, George finds that business and a family keep him well occupied, but he does manage to have time for an occasional round of golf.

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Blinded Servicemen Back to Industry

The work of training blinded servicemen to take their places back in the community with qualifications making them as good as, or in some cases better than, sighted workers, is proceeding at the training centre in Auckland known as the New Zealand St. Dunstan's.

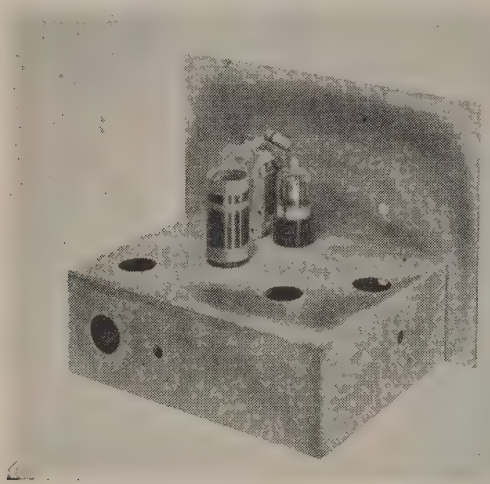
New Zealand St. Dunstan's is the hostel and training centre administered by the Blinded Servicemen's Trust Board, Inc., and here, in the course of training, blinded and partially-blinded servicemen learn to occupy their working and leisure hours with activities selected so that their blindness is little or no handicap. It is the aim of New Zealand St. Dunstan's to train a man during a brief course of intensive re-education to a standard where he can return to his home town and find pleasant and remunerative employment in such a factory or workshop for which he may be fitted.

In determining what types of work a blind man is capable of succeeding in, New Zealand St. Dunstan's has very little precedent in this country on which reliance can be placed, but already success has been achieved in carton manufacture and armature winding. Current trainees are doing well at joinery, toy manufacture, and nursery gardening. It is felt that in the industrial factories of New Zealand, there must be many operations that could be easily taken over by blinded men. Certain classes of assembly work and certain classes of gauging precision machine parts should provide fields in which the greatly-sensitised touch of a blind person will more than compensate for the loss of sight. It would be greatly appreciated if readers of this article will apply their knowledge of individual processes in bringing to the notice of the Blinded Servicemen's Trust Board any processes that may be worthy of investigation as a possible avenue of employment, or, better still, if any employer reading this would be good enough to invite representatives of New Zealand St. Dunstan's to demonstrate in a practical way their ability to infiltrate themselves into industry. It is the co-operation of workers and employers that we ask for in giving us access to their knowledge and to their factories to test these specific processes with a view to making a final step in a man's rehabilitation that is, permanent, congenial employment in his own home town or district, in daily contact with sighted workers and companions.

The Editors of "Radio and Electronics" have conferred with the Director of the Blinded Servicemen's Trust Board on this subject, and so impressed were they with the manner in which this body is functioning and with the results so far obtained, that they have no hesitation in recommending that interested firms should make every endeavour to investigate the possibilities suggested above. "Radio and Electronics" will be pleased to handle any correspondence relating to the employment of blinded ex-servicemen.

THE RADEL "PROGRESSIVE" BATTERY THREE

In designing the Progressive Battery Three, we have taken into account several factors of considerable interest to the home constructor. It is intended from the constructional point of view to meet the requirements of those who are new to the building of sets on a metal chassis. Since the details of such a set differ quite markedly from the equivalent bread-board mounted set, and because in a set of this type proper shielding is imperative if the best results are to be obtained, we are describing the set in several instalments. Each instalment gives

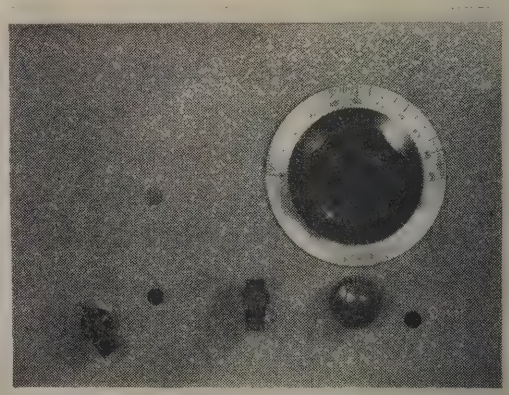


Showing the layout of parts for the first stage of the construction.

the constructor a complete receiver which will perform excellently in its class, but successive instalments add new features which improve on the performance of the preceding set. One very good effect of treating the construction in this manner is that each modification may easily be made and the result tested by actual working from the air, as it were. In this way any faults which occur are isolated in the portion which has just been completed, and the constructor is unlikely to end up with a set which does not perform properly, and which has to be taken to a professional radio man to be put into working order.

THE PLAN OF THE SET.

Briefly, the plan followed, both in this series of articles and in the construction of the set, is as follows. First, the chassis for the complete set is built, including from the start all large valve and coil holes. A working plan of the chassis and front panel is shown on this page. Next, the first part of the set is constructed using only one valve. This is a 1D8-G, and is wired up as a regenerative triode detector resistance coupled to a pentode stage of audio amplification. A glance at the circuit will reveal that it is the same as was used for the Radel One, which appeared in *Radio and Electronics* some months ago. This little set was such a

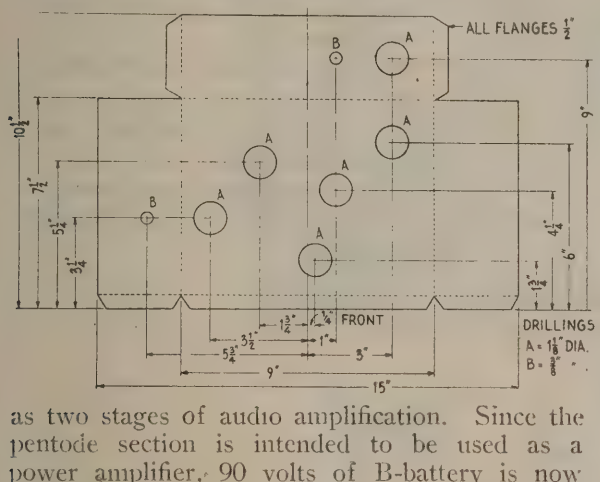


The front panel, with the controls mounted for the first stage of construction.

good performer that it was considered quite unnecessary to alter the design to make it suitable for our present purpose. The next stage is to add a 1N5-G as an untuned R.F. amplifier. This gives useful gain without introducing the necessity for top-panel shielding, or for any further controls. It will work quite well from the 45v. used for the first portion of the set. After this, the R.F. stage is tuned, giving greater gain and, this time, an increase in selectivity. It is at this point that the more inexperienced constructor is likely to find difficulty, since now, proper shielding becomes necessary, and careful adjustment of coils is required so that the R.F. and detector tuning controls may track with each other reasonably

well. The controls will not be ganged, since this adds further complications and only a small advantage in the elimination of one control. In fact, a separate R.F. tuning control can have the distinct advantage of ensuring that the R.F. stage is always exactly tuned, so that there are no losses from ganging errors.

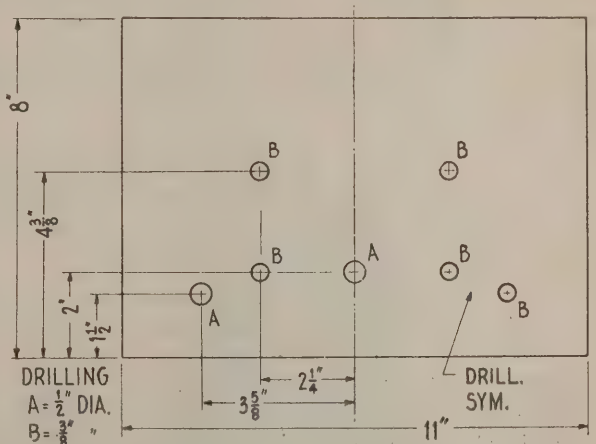
Up till now, the set is intended for headphone operation only. The final step, therefore, is to replace the triode section of the 1D8-G by a 1H4-G, and to rewire the 1D8-G



as two stages of audio amplification. Since the pentode section is intended to be used as a power amplifier, 90 volts of B-battery is now used, and, with the additional gain provided, the set becomes capable of giving good loud-speaker volume on even weak stations. Thus, the final line-up is:—1N5-G tuned R.F. amplifier, 1H4-G regenerative detector, triode section of the 1D8-G as first audio stage, and pentode section as output tube.

THE CHASSIS.

This should be made exactly according to the plan given, from 18-gauge iron. The purpose of the various mounting holes may be outlined thus:—The hole on the extreme left of the chassis top takes a valve socket for the plug-in R.F. coils. To the right and behind this is the hole for the R.F. tube socket. Almost in the centre at the front of the chassis comes the detector valve and nearly directly behind it is the hole for the detector coil socket. In the top right-hand corner is mounted the output tube. At the back of the chassis, close to the latter, is the hole for the loud-speaker plug, and next to it a ⅜ inch hole through which are led the battery connecting wires. The photographs show the set in its first stage. Next to the tuning condenser is the 1D8-G, and in front of both is the detector coil. It will be noted that, with this layout, all small components and connecting wires are under the chassis with the exception of the grid leak and grid condenser. The wire from the tuning condenser to the "hot" end of the grid coil is taken through the chassis from underneath the tuning condenser. The type of condenser shown is strongly recommended for this set since these condensers are very well matched and will minimise any tracking difficulties which may arise. The stator has a connecting lug at each end so that the above-mentioned lead is connected to the bottom one, and the grid-leak condenser combination to that at the top. Underneath the chassis all wires carrying R.F. should be run with solid tinned copper wire of fairly heavy gauge. Anything up to 18 gauge is suitable. The leads referred to are those to the reaction condenser, the lead from the tuning condenser to the grid coil, and the aerial and earth leads. A ⅜ inch hole has been provided in the left-hand side of the chassis through which aerial and earth leads should be taken. The photograph of the front panel layout shows controls as follows:—At the left is the On/Off switch for the batteries. In the centre is the 'phone jack and next to it is the reaction condenser control. The large dial of course is the detector tuning control. The remaining three holes are to be used in the completed set. The one at the left near the



centre is for the R.F. stage tuning control, while the one underneath this is for the R.F. gain control. The unoccupied hole on the right is for an audio gain control.

COIL DATA.

If the constructor has previously built the Radel One, the coils used for this set can be

retained at least for the first portion illustrated here. Unless there is room for a primary winding on the formers, fresh coils will have to be wound when it comes to adding the R.F. stage. For convenience, the table of coil data for the Radel One is reproduced here. The tuning condenser in this case is 0.0003 *f*, so that some alteration of the broadcast coil may be necessary in order to cover the band properly. The best plan, if the set is being constructed for the first time, is to wind the grid coil with about 10 more turns than specified. This should bring 2YA too far out on the condenser, and will cause the high frequency end of the broadcast band to be off the dial. Turns can now be taken off, say, two at a time, until 2YA is received with the condenser almost fully meshed. If this is done, the broadcast band up to 1600 kc/s. should be located on the dial. The short-wave coils specified have plenty of overlap, so that the high frequency coil should not require alteration. It may be found, however, that the 80-metre amateur band is off the dial at the low frequency end if the intermediate coil is used as specified. This band is easily located by listening, so that the proper procedure for accurately constructing the intermediate coil is the same as that outlined for the broadcast coil. Three or four turns too many should be used for a start, and turns removed one at a time until the 80-metre band is found near the fully closed position of the tuning condenser.

Constructing the set on a metal chassis may necessitate some slight alteration in the number of tickler turns required, but as long as the number of turns specified enables the set to be brought into oscillation at all points of the dial, no change will be needed.

In our next issue, we will describe the coil changes and the additional construction required to put the untuned R.F. stage into operation. This type of stage is comparatively unknown to radio enthusiasts, but has two very important advantages when attached to a simple regenerative detector. Its gain, though not as high as

(*Continued on p.* 48.)

COIL DATA.

Broadcast.

L_1 105 turns 36 gauge enamelled wire, close wound.

Shortwave A (approx. 30m.-90m.)

L_2 30 turns of same wire, close-wound.

L_1 16 turns 24 gauge enamelled wire, double spaced.

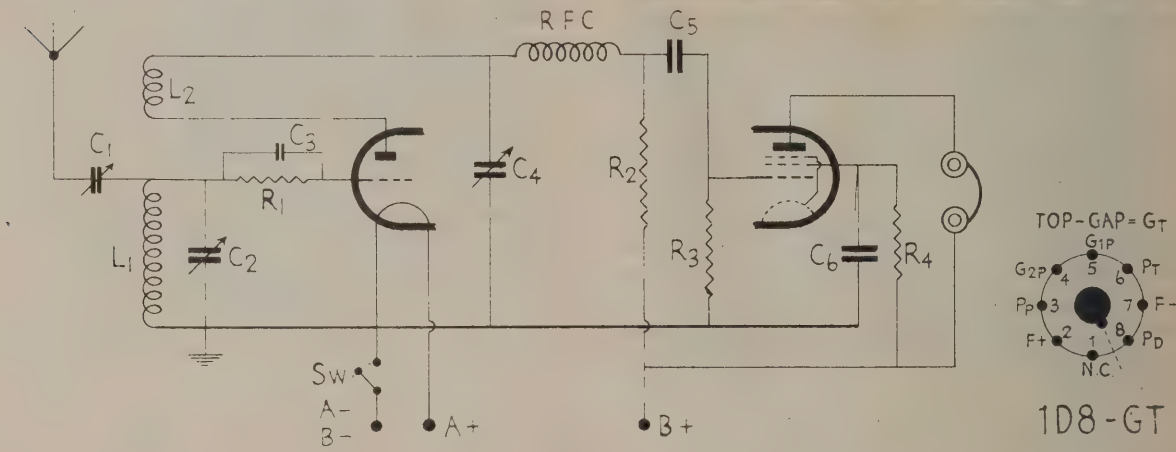
L_2 10 turns of same wire, close-wound.

Shortwave B (approx. 19m.-60m.)

L_1 6 turns 24 gauge enamelled wire, double spaced.

L_2 10 turns of same wire, close-wound.

Note.—All tickler coils spaced $\frac{1}{8}$in. from top of grid coil.



C_1 = 30$\mu\mu f$. max. trimmer.
C_2 = 0.00035μf. max. variable.
C_3 = 0.0001μf. mixed.
C_4 = 0.0003μf. max. variable.
C_5, C_6 = 0.1μf.
R_1 = 2 Megs.
R_2 = 50,000ω
R_3 = 5 Megs.
R_4 = 20,000ω

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A Practical Beginners' Course

Part 2—THE FIRST CRYSTAL SET

Last month we talked a little about what radio is and what a radio set is expected to do. We also described most of the parts which would be required for building our first set. The only thing which was not described we purposely left till this issue, since its action will need some explaining. This is the crystal detector.

THE CRYSTAL DETECTOR.

This component can well be described as the heart of the crystal set, for without it the set cannot function at all. It consists of two main parts. A metal cup, which holds the crystal, and some arrangement to hold a fine piece of wire, the "cat's whisker," and to allow the latter to be placed in contact with any point on the surface of the crystal. In the photograph the construction of the detector can be clearly seen. Connections are made to it by attaching wires to the crystal cup and the metal mounting of the "cat's whisker." Before attempting to describe how the crystal detector works, we will explain first the signs or symbols used to indicate the various components on a circuit diagram, and secondly how the simple crystal set is made.

CIRCUIT DIAGRAMS.

If we set out to build anything at all, much the best way is to have a plan or a drawing of what we are going to build. Whether we are constructing a bookcase, a model aeroplane, or a radio set does not matter—a plan of the article is essential. This is because we do not always build things which we design ourselves, and also because plans and diagrams can convey in a very small space information which would take thousands of words to describe if it were not possible to draw a plan. For instance, to build the set we are about to describe, all that an experienced constructor would need would be a circuit diagram and a short list giving the exact specifications of the parts shown in the diagram. To one who has never built a set, it is necessary to explain what the symbols of the diagram mean, but after he has mastered a few simple facts he, too, will be able to look at a circuit diagram and know what it means in terms of the actual components which go to make up the set.

What is a Circuit Diagram?

A circuit diagram is simply an electrical plan of any device which is made up of electrical components. In it no attempt is made to show what the completed article actually looks like. In the case of radio sets, this would be almost impossible, owing to the fact that the actual size and shape of most electrical components have very little to do with their electrical specifications. When we were describing a condenser in our last instalment, we pointed this out. Thus, in circuit diagrams, all condensers of whatever type are represented by the same symbol, and their electrical size or capacity is shown by writing this alongside the symbol. It can be seen, therefore, that a circuit diagram tells us (a) what components are used, (b) their electrical specification, and (c) how the components are connected together by means of wires. The circuit diagram does not tell us such things as how the various parts are mounted, or how they are placed on the base board or metal chassis of the set. These things can be shown by photographs or ordinary plans.

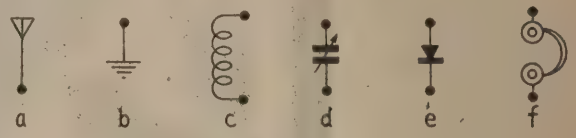


FIG.1

SYMBOLS USED.

In Fig. 1 are shown the symbols used in drawing circuit diagrams using all the components we have so far described. A coil is shown by means of the symbol c, third from the left. Similarly, d is the sign for a variable condenser, e represents a crystal detector, and f a pair of headphones. The small dots at the ends of the connecting wires represent the terminals of all these components, and it can be seen that each of them has two terminals. The first two symbols have only one terminal each, because a is the sign for an aerial, and b is the one for an earth connection. We saw in Part I that an aerial is simply a piece of wire erected some distance above the ground. One end of it is brought inside the house and attached to the aerial terminal of the set, so that the aerial has only one terminal, representing the end that is brought inside. An earth, in the radio sense, is a piece of wire connected at one end to a piece of iron pipe sunk in the ground, and at the other to the earth terminal of the set. So it, too, has only one terminal on a circuit diagram, the horizontal strokes representing the pipe buried in the ground.

The terminals of a coil can be simply loose pieces of the wire used to wind the coil, or, rather, an extension of the coil wire itself. This will be the case in the coil we build for the crystal set, but manufactured coils usually have lugs to which the ends of the coil are connected, and to which the connecting leads are soldered.

The terminals of the crystal detector are the metal parts of the crystal cup and the "cat's whisker" mounting themselves, or can be solder lugs held down by the nuts which mount these parts to the base board.

The terminals of the headphones are the metal tips attached to the flexible wire leads coming from the ear pieces.

BUILDING UP A CIRCUIT.

Fig. 2 is the circuit of the simplest crystal set, the first we are going to build, and uses only the parts whose symbols are given in Fig. 1. It will be noticed that the dots representing the terminals have been left out, since this is always done in practice. The lines joining the components together

can be looked upon as representing the wires used to connect between the terminals of the components. Supposing, for a moment, that we have all the parts ready to be assembled, the circuit of Fig. 2 would be built up in this way. First, the terminals of

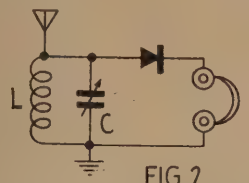


FIG.2

the tuning condenser would be connected by means of wires to the ends of the coil. Next, one tip of the headphones would be connected to one end of the coil, and therefore at the same time to the tuning condenser. The other tip of the headphones is now connected to the crystal cup, and the metal mounting of the "cat's whisker" is connected to the other side of the already joined coil and condenser. The circuit has now been completely wired up, except for the aerial and earth. Assuming that these two have already been constructed, all that remains to place the set in working order is to connect the free ends of the aerial and earth wires to the appropriate points on the circuit. It will be noted that on Fig. 2 the aerial is shown connected to the top of the coil and the earth to the lead from the condenser, which goes to the bottom of the coil. To the newcomer, it might seem that, if the aerial had been connected to the lead from the top plate of the condenser instead of at the coil as shown, the circuit would be altered. However, this is not the case, since the connecting wires have no purpose except to join the components together, so that connecting the aerial to any point on the wire shown joining the top of the coil to the crystal detector and to the top plate of the condenser has the same effect.

There is one point we have not mentioned in regard to the variable condenser. When you are wiring up this component, the frame of the condenser should always be connected to the side of the circuit which is going to be earthed. This is because the moving plates are connected to the frame, and the fixed plates are insulated. Connecting the earth wire causes the earthed side of the circuit to have no signal voltage on it, so that touching this part of the circuit will have no effect on its operation. If the insulated plates are connected to the earthed side, the moving plates, and therefore the frame, will be on the aerial side of the circuit, and touching this—as may be done when tuning—will decrease the strength of the signal. For the same reason, the circuit should always be wired up as shown, with the 'phones also on the side of the circuit which is to be earthed. For instance, although the set would still work if the aerial and earth were interchanged on the diagram, the operation would probably be erratic and undependable.

CONSTRUCTIONAL DETAILS.

So far, no mention has been made of just how the parts of the set should be arranged, or how they should be mounted. This question is almost as important as connecting the parts correctly in the circuit, for, unless the parts are rigidly mounted and the wiring is made in such a way that the operations of tuning and adjusting the crystal do not disturb the wiring, the performance of the set will not be the same from one minute to the next. Although this is not so important in crystal sets as in valve sets, the constructor should learn as early as possible the correct methods of building so that, when more complicated circuits come to be built, no troubles will occur due to poor construction.

The coil is to be wound on cardboard tubing 3in. in diameter. The tuning condenser is provided with feet for screwing to a base board, or with a nut on the main shaft, so that it can be mounted on a vertical panel. The crystal detector must be mounted on the base board. Terminals must be provided for aerial and earth and for the 'phones, because these cannot be permanently soldered on to the rest of the circuit. All these things make it necessary to have a rigid support on which the components can be mounted before the connecting wires are soldered into place. For crystal sets, the simplest and probably the best thing to use is a small piece of solid board, ¾in. or so thick and about 10in. by 12in. in size. This is much larger than is needed for our first sets, but can be used over and over for all the new circuits as we come to them, including a good many of the simpler valve sets.

Winding and Mounting the Coil.

We will assume that you have bought six inches or so of the 3in. coil former and a quantity of 24-gauge D.C.C. wire. The best way to mount the coil is with two small right-angle brackets which can be made by bending two small pieces of brass or aluminium and drilling a small hole in each half, one of which is held to the coil former with a small nut and bolt and the other screwed to the base board. The brackets, of course, can be bought if desired. In any case, it is best not to attach them to the coil former until after the winding has been done. First of all, make two holes ¼in. from the bottom of the coil former and opposite each other. These are the holes for the mounting brackets. The coil should start half an inch from the bottom of the former. In order to start the winding, make two small holes one-eighth of an inch apart and half an inch from the bottom of the former. These holes need only be big enough to allow the wire to be threaded through them, and can be made with a heavy darning-needle or the point of an awl.

Next, take the end of the wire and thread it through one of the holes from the outside, leaving a free end about 6in. long. This end will now be inside the former. It is now threaded from the inside through the second small hole and pulled tight. Now, both the free end and the main part of the wire are on the outside of the former. Since the coil will require 70 turns, and the former is three inches in diameter, measure from the reel about 60 feet of wire and cut it off. It is important when doing this not to allow kinks to occur, as these permanently weaken the copper wire and will sooner or later break. Next, the far end of the wire is attached to something solid, such as a door-handle, by taking a few turns round the handle and then twisting the end several times round the wire. Then, taking hold of the former at the other end of the wire, walk straight away from the door-handle until you have the wire stretched tightly. During this operation, too, it is important not to get a kink in the wire. Now pull firmly, but not too hard, on

the coil former, making sure, by holding it with your thumb, that the wire does not slip through the holes in the former. As you pull, the wire will stretch, so continue pulling until the stretching is about 6in. If you have managed to cause a kink in the wire, it will probably break at the kink when it is being stretched.

The reason for stretching the wire like this is that, once the coil is wound, it will not become loose on the former, but if the coil is wound without previously stretching the wire, after a time the turns may become loose. To wind the coil, after stretching, hold the former at right angles to the direction of the wire. It is best to stand facing along the wire with one hand holding the end of the former. With the wire held tight (but not tight enough to stretch it any more), turn the coil former towards you. This will wind the first turn on the coil, and when the starting point comes round to meet you again the wire should be touching at the place where it comes through the former to start the coil. After winding on the first turn, inspect this to see that it winds straight round and does not bulge outwards or inwards. If it does, keep the wire tight with one hand and push the turn in or out along the coil former with the other. If everything is all right at this stage, keep on winding by turning the coil former towards you and walk with it as the wire gets shorter. At the same time as doing all this, you must count the number of turns as you put them on. When the right number of turns has been wound, making sure that all the turns nest firmly up against one another, snip off the wire about a foot from the coil. Be careful to hold the last turn in place with one hand. If you let it go, the coil becomes loose, and the only thing to do is to go right back to the beginning and start again.

Then, holding the wire, make two small holes through which to thread the finishing end. The holes should be as close to the last turn as possible, and one-eighth of an inch apart as before. Thread the free end through the first hole, then back again through the second. This will bring the finishing end to the outside of the coil, when it can be pulled tight. After this, the wire will not slip and the job is complete.

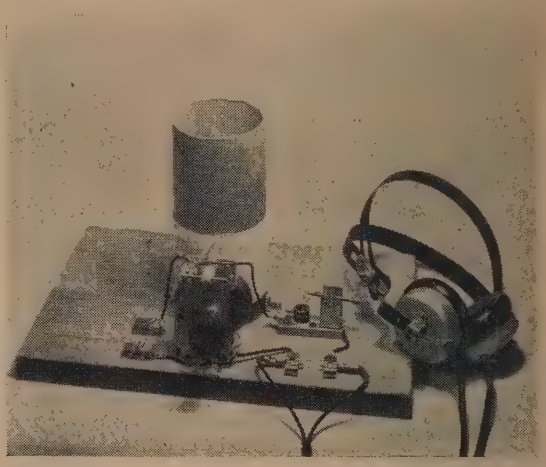
MOUNTING THE COIL AND CONDENSER

The coil can now be mounted on the base board. First, attach the brackets to the coil and then screw them to the base board with small wood screws. The coil should be positioned so that there is room between it and the front edge of the base board for mounting the condenser. If this is the type which has feet, it can be mounted directly on to the base board with wood screws, and no panel is necessary. If it is of the single-hole mounting type, a front panel will be necessary on which to support it. This can be made from a piece of three-ply screwed to the front edge of the base board. A $\frac{3}{8}$in. hole is made in the panel at a suitable height, so that the condenser, when mounted, clears the base board. The condenser shaft is inserted in the mounting hole and the nut tightened.

CRYSTAL DETECTOR AND TERMINALS.

For this type of construction, the best things to use as terminals are Fahnestock clips. These may be screwed to the base board in any convenient position and leads soldered to them. For this set four will be required—two for the headphones and one each for the aerial and earth.

Mounting the crystal detector will depend on the type purchased. The one we have described usually has a mounting hole for the "cat's whisker" support and another in the bottom of the crystal cup. These components can then be screwed to the base board, slipping under each a solder lug to which connections



are made. When all the parts have been mounted in this way, the circuit may be connected up as described above.

SOLDERING.

One of the most important things in building even such a simple set as this is the making of good soldered joints. When a soldered joint is properly made, the solder becomes a part of the metal which is being joined, and is not at all like glue in its action. The principle is simply this: The two parts to be joined are thoroughly cleaned so that they present a bright, untarnished surface. The soldering iron is applied to the parts, which become heated to the same temperature as the drop of molten solder on the tip of the iron. When they have reached this temperature, the solder automatically flows on to them. Now, if the iron is removed, the solder immediately solidifies, firmly joining the two parts together. If the parts to be joined and the iron itself are the slightest bit dirty, the solder will not flow on to the parts, and although, after the iron is removed, the solder may hold the parts together, the result will not be a properly soldered joint. In order to ensure that the solder flows properly when the joint is made, each part should be "tinned" separately before attempting to make the join. "Tinning" simply means coating the part with a thin film of solder. It is best done as follows. First, the part is scraped or cleaned with a piece of fine sandpaper, thus exposing a new, bright surface. A very small smear of flux is placed on the part to be "tinned." Next, it is important to see that the soldering iron itself is clean. In order to work at all, it must be "tinned" also, or a drop of solder will not stick to it when hot. It is a good plan to plunge the tip of the iron into the flux and wipe quickly on a clean piece of rag kept for the purpose before each "tinning" or joining operation is attempted. Having cleaned the iron in this way, rub it on the part to be "tinned" until the solder can be seen to take. When both

parts are "tinned," soldering them together is very easy and can be done with the smallest amount of solder. If the few points mentioned here are carefully followed, no trouble will be experienced in making good joints.

OPERATING THE SET.

First of all, connect the aerial and earth to the right terminals and the 'phones to their Fahnestock clips. Next, insert the crystal in the cup and screw tight the small bolt which holds it. **It is very important** in doing this not to touch the surface of the crystal with the fingers, as even the minute amount of grease that is always on them will prevent the crystal from working well if it gets on to the surface. Crystals are usually sold with a small pair of forceps, which should be used for handling, and the greatest care should be taken to prevent dust from getting on the crystal. It is a good plan, when the set is not in use, to place an inverted glass over the whole detector to exclude dust, for this can lower the sensitivity of the crystal very quickly.

Next, take a pair of scissors and cut a small piece off the end of the "cat's whisker" in a slantwise fashion, so as to leave a sharp, bright point. On no account touch this point with the fingers. Take the adjusting handle in the right hand, and, with the 'phones on, very gently place the "cat's whisker" in contact with the crystal in such a way that it stays put, but with the minimum pressure on the crystal from the spring in the "cat's whisker." Then, tune the set with the variable condenser until a station is heard. If, after carefully and slowly tuning over the dial, no station can be heard, try adjusting the "cat's whisker" to a different spot on the crystal and tune again. When a station is heard, set the condenser at the point where it comes in loudest. You can then try further adjustments of the crystal detector to find the most sensitive spot. Always treat the crystal very gently, as its surface is easily scratched and the sensitive points ruined. When more than one station is transmitting, you may be able to tune one station out and the other in with the condenser.

This set has several limitations. In fact, it is not an ideal crystal set by any means. It is merely the simplest and easiest circuit for a beginner to build. However, there is practically nothing to stop it from working except a poor crystal or insensitive headphones, so that it is much the best to start with. Do not let any of your more knowing friends deter you from starting with it, because, as they will point out, it has several disadvantages. Find out for yourself what these disadvantages are by building it and doing all you can to receive as many stations as possible. Next month we will discuss these disadvantages and go on to show how they may be overcome by using slightly more complicated circuits and construction.

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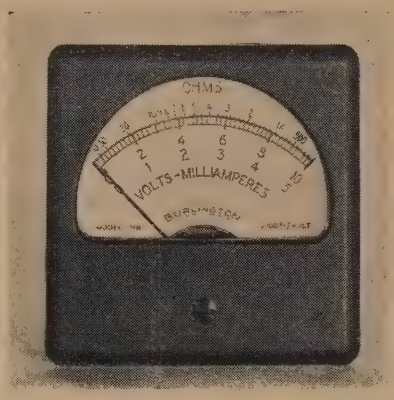

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OUR GOSSIP COLUMN

NATIONAL CARBON ENTERTAINS

One of the most pleasant functions held for a long time was the National Carbon Company's cocktail party, held in the Reception Room of the Royal Oak Hotel last month.

R. Slade T. L. Jamieson S. Cory-Wright R. R. Hayman L. Rountree B. Rundle A. H. Duncan

The many guests thoroughly enjoyed themselves, and the part played by the hosts, Ron. Greenwood, Managing Director, and Charles Hart, Sales Manager, contributed largely to the success of the evening.

The toast to the King was proposed by Charles Hart, and "Our Guests" by Ron Greenwood. Ron excelled himself by making an excellent speech, which is quoted below:—

"It gives me great pleasure to participate in this function, the primary object of which is one of thanks.

"During the war years you all knew of the heavy munition task to which we were committed and the conditions which thereby precluded our supplying your full requirements at that time, but you were extraordinarily patient, tolerant, and helpful during those years, and now that we have overcome, in the main, the difficulties which we then experienced, we are taking this opportunity of saying 'thank-you' for your co-operation at that time.

"In offering our greetings to you and the Companies which you represent, we are joined by the Board of Directors in Sydney, whose Chairman, Mr. Ewart Brisbin, has to-day sent us the following cablegram:—

> Greetings to all those present at your party to-night. As you raise your glasses in honour of your guests, please express this company's sincere appreciation for their splendid friendship and continued co-operation over the past number of years. I truly regret not being able to be with you all to-night on this happy occasion.

"If Mr. Brisbin could be here to-night, I know that he would tell you of the excellent prospects with which we are now confronted in the immediate future. This function to-night is an indication of this because, as one guest mentioned to me as he came into the lounge this evening, 'You wouldn't have been game to hold this party two years ago—supplies were so short then that we would all have torn you apart!'

"In welcoming you to this party to-night, may we again say how we appreciate your coming along and joining with us in what we hope to be a successful function. I call upon all members of our Company who are present to-night to honour the toast of 'Our Guests,' with the wish that both they personally and the firms which they represent will enjoy many years of continued prosperity."

Mr. Alf. Duncan, of J. R. McKenzie's replied, and the gathering then broke up into small groups and the serious proceedings of the evening commenced.

R. D. Greenwood K. Stephen G. McLennan C. H. Hart R. S. Donovan I. Gunn R. A. Lulham

Among the guests were Messrs. H. E. Taylor and P. Erskine, of British General Electric Co.; C. J. Lenihan and R. R. Hayman, of Turnbull and Jones, Ltd.; F. Giles, of Woolworths (N.Z.), Ltd.; S. Shea, of "Radio and Electronics"; A. Aitken and L. Rountree, of Charles Haines Advertising Agency; R. Slade, of Philips Lamps; D. B. Brown-Douglas, of John Burns and Co., Ltd.; W. L. Packer, of Fairbairn, Wright, Ltd.; R. S. Donovan, of National Electric and Engineering Co.; K. Stephen and W. I. Cunninghame, of H. W. Clarke, Ltd.; Alf. Gibbons, of Hope, Gibbons, Ltd.; F. R. Jones, R. K. Jones, and Mervyn Jones, of Jones Bros., Ltd.; A. H. Duncan, of J. R. McKenzie's, Ltd.; I. Gunn, of Jas. J. Niven and Co., Ltd.; A. I. E. Jones and G. D. Campbell, of Bank of New South Wales; V. R. Earnshaw and E. H. R. Green, of P. and T. (Engineers' Department); B. Rundle, of Western Electric; J. H. Turner, of Hunt (Ernest) Turner and Co.; S. Cory-Wright, of Cory-Wright and Salmon; and F. Birmester, of Sargood, Son and Ewen.

We regret to record that Mr. Flaunty, of H.M.V. Retailers, Wellington, was badly injured as a result of a car accident. The car was completely wrecked, and from all accounts he was lucky to escape with his life. Although it will be some months before Mr. Flaunty is again active, we wish him a speedy recovery.

* * *

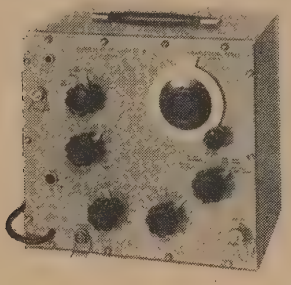
Mr. H. R. Halliday has been appointed Manager of International Radio Co. Pty., Ltd., Sydney, Australia.

Born in Western Australia, Mr. Halliday trained with Messrs. Atkins (W.A.), Ltd., in their electrical engineering department. He graduated in Arts at the University of Western Australia, and secured the Diploma in Mechanical and Electrical Engineering at the Perth Technical College. He is an Associate Member of the Institute of Engineers, Australia, and of the Institution of Electrical Engineers of Great Britain.

Mr. Halliday went to England in 1930 and joined the super-tension staff of Enfield Cables, Ltd., London, and was engaged on research, manufacture, testing, and installation of cables up to 132,000 volts. In 1934 he returned to Australia as resident engineer for Enfield Cables, a position he held until his recent appointment.

* * *

Mr. P. C. Collier, of Collier & Beale, Ltd., Wellington, has arrived back in New Zealand after an extended tour in England and America.



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Major Ken Collett has just been released from the Army and is now back with his old firm—Radio Corporation of N.Z., Ltd. Joining the Army in the very early days of the War, he saw active service in the Middle East and was commissioned there, being promoted to Captain in Signals. On returning to New Zealand, Ken was chosen as a member of the New Zealand Radio Team sent to England at the request of the British Government. During his tour of duty in England he was promoted to Major.

Mr. E. Wilson, of Wilson's Radio, Napier, was a visitor to H.M.V. Head Office in Wellington. Like many radio dealers, he was most probably stock-hunting.

Mr. Smith, of Wireless Service Co., Ltd., Hastings, was in Wellington recently and called on most radio houses. We know, because we met him in most radio houses.

"Pop" Harper, of Wanganui, reports that things are too busy to spend time in drinking a cup of tea. We would like to recommend another telephone extension for "Pop"—one does not appear to be sufficient to deal with all the S.O.S. calls!

Jack Hobbs, also of Wanganui, is another of those young fellows rehabilitating themselves in the radio and electrical business. His new venture is his main hobby, and his keenness should pay dividends in the days to come.

Mr. Norm. Swann, of Swan Electric, has just returned from Australia after a visit lasting about a month. While in Australia he spent most of his time with Rola. Norm. is becoming quite a globe-trotter.

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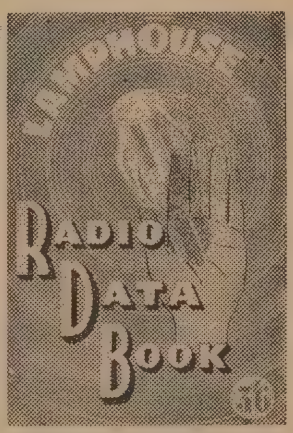

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RADAR *(continued from page 6)*

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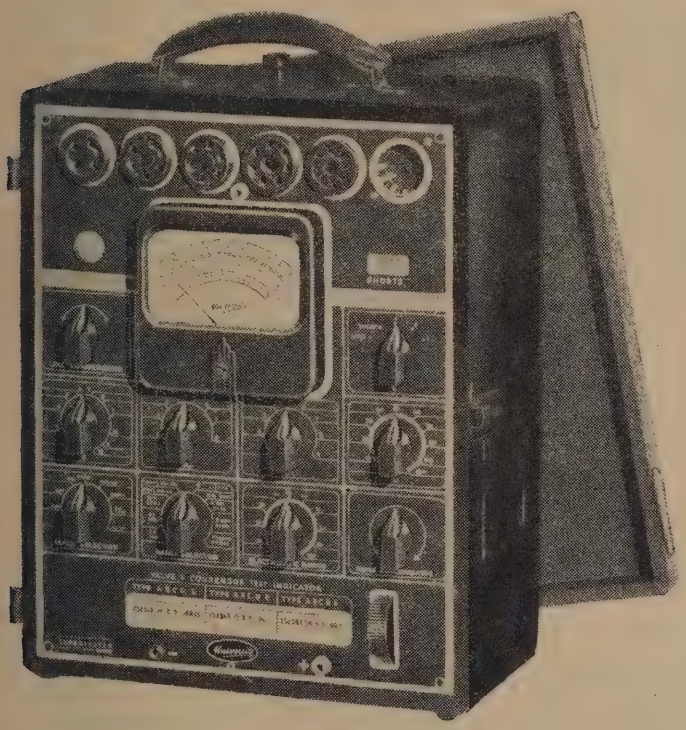

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AERIALS FOR 10 METRES

(continued from page 15)

line may be directly connected to the aerial without any matching device at all, and a very close match obtained. On the practical side, the spacing of the two wires of the aerial can be about six inches. Both wires should be pulled tight so that the wind will not cause them to alter their position with respect to each other, but swing as a whole. The 300-ohm line can have any desired spacing as long as the ratio of wire diameter to spacing satisfies the formula given in the amateur literature for the impedance of two-wire lines.

Fig. 3 (c) is a directional array of a simple type, but gives quite good gain and directivity along a line perpendicular to the run of the wire. The impedance at the centre is high enough for the direct connection of a two-wire line, but in this case will vary considerably with height above ground and the proximity of metallic objects (roofs, etc.), so that no set figure can be given. The correct matching can be obtained by the use of a stub in the manner described in the literature. It is not intended to go into the question of stub-matching here, but this will be dealt with in Part II of this article, as will the question directional arrays.

(to be concluded)

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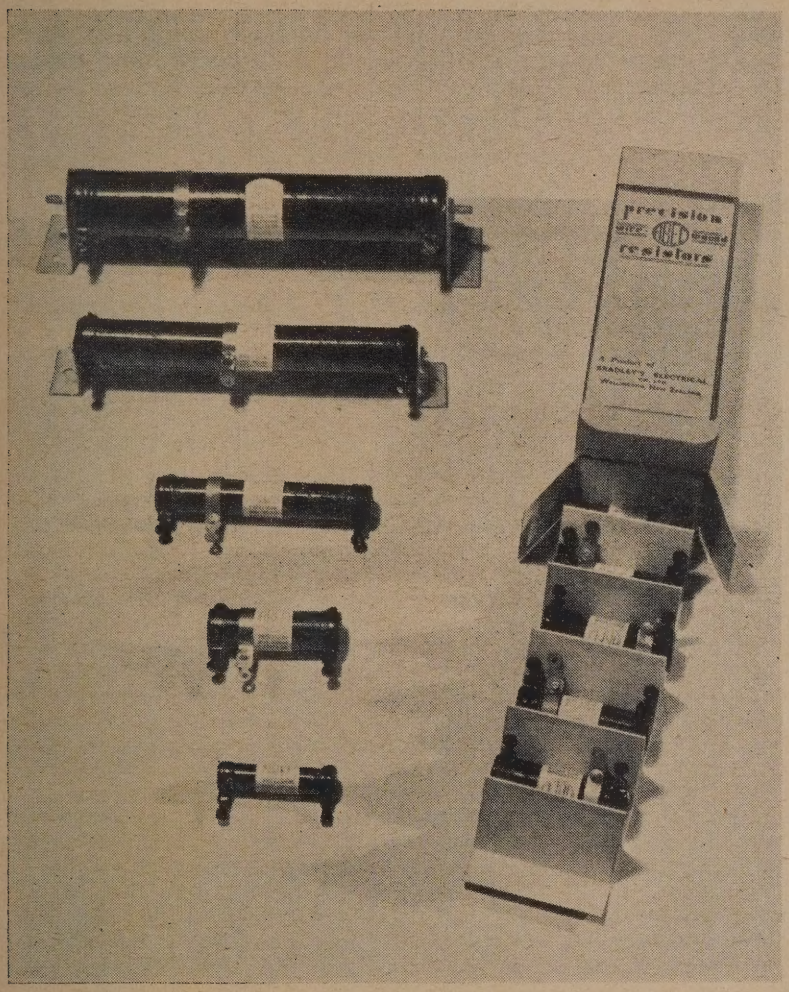

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CAPACITY ANALYSER

(continued from page 10)

for electrolytics the following table holds reasonably well:—

Up to 5%	.....	Condenser 100%
5% - 10%	.....	Condenser good
10% - 15%	.....	Condenser fair, but passable
15% - 20%	.....	Condenser doubtful
Over 20%	.....	Replace condenser

FURTHER POINTS.

If the analyser is to be in continuous use, the A.C. switch S_4, which may be mounted on the sensitivity control R_{14}, could be used instead to switch off the H.T. voltage to V_1, leaving the filaments heated and the instrument ready for immediate use.

Contact 1 on $S_1(b)$ is used to discharge condensers after leakage-testing, before removing them from the test terminals. This will prevent accidental shocks, and position 1 can also be used when connecting condensers to be tested, for the same reason.

The heater winding on the power transformer has been purposely left unearthed, since earthing it would exceed the rated heater-cathode voltage of the 6X5.

S_1 SWITCH POSITIONS.

Capacity.		Leakage.
Position 1, dial reading x 0.0001	.....	Discharge
Position 2, dial reading x 0.001	.....	100 volts
Position 3, dial reading x 0.01	.....	200 volts
Position 4, dial reading x 0.1	.....	300 volts
Position 5, dial reading x 1.0	.....	400 volts
Position 6, dial reading x 10	.....	500 volts
Position 7, dial reading x 100	.....	Open

ELECTRONICS

(continued from page 28)

While during the war the science of electronics has made amazing strides, and undoubtedly advanced more rapidly in a few years than it might otherwise have done in more than a decade, one should not be tempted to expect the marvels of new electronic devices in the immediate post-war future. Most of the new developments were made for direct war uses and many of them will never find peace-time applications, while for others it may take two years before they can be used in the design of peace-time products.

Radel Progressive 3 -

(continued from page 34)

a tuned stage, is appreciable, and it effectively isolates the detector from the aerial. This means that there will be no tendency for the detector to be pulled out of oscillation by the latter, and that much more effective coupling can be used. Altogether, the untuned R.F. stage renders the set easier to handle, and at the same time gives a considerable increase in the strength of weak signals.

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ER46/T55

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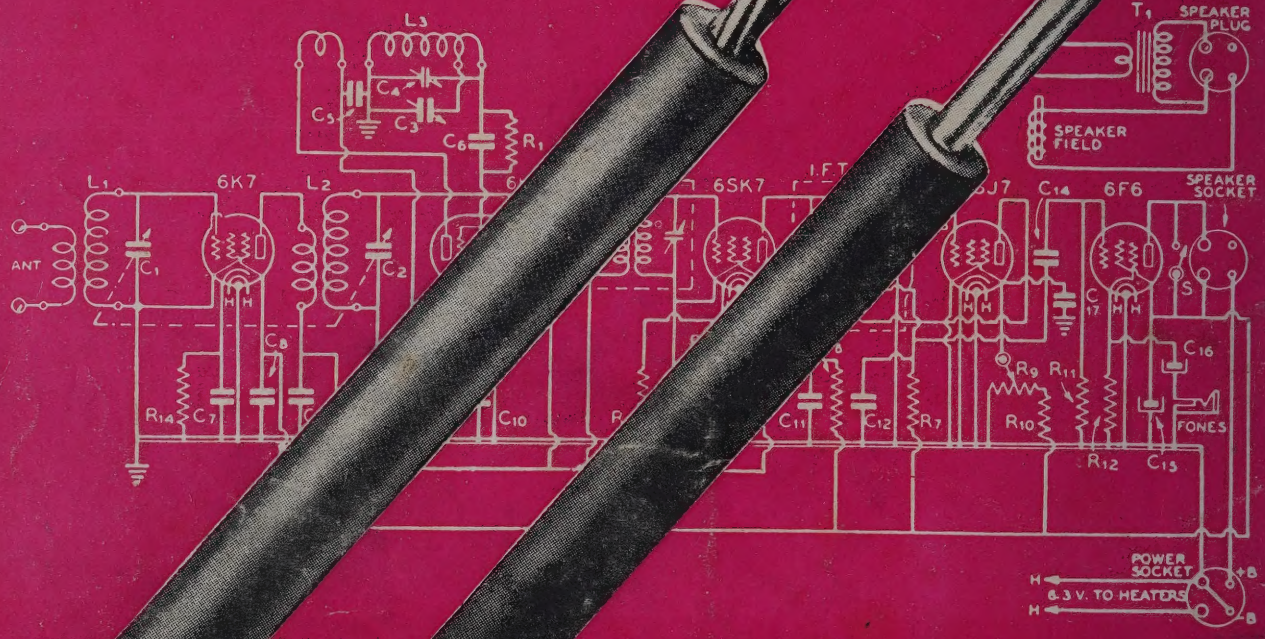

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